YAROSLAV KLYUSHIN

ELECTRICITY, GRAVITY, HEAT – ANOTHER LOOK

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KLYUSHIN'S PREFACE

This book was conceived as a challenge to the crestfallen conformism in science. And any such challenge is addressed first of all to the youth cognizant of the laws of nature for the first time, and therefore potentially more inclined to perceive non-standard ideas.

My words are to you, student and postgraduate. Your life will not be devoted to specification of the hundredth digit of a well-known constant. The very foundation of modern physics has collapsed, and its edifice is tumbling down. You will have space to develop, and subject to think over. To realize and formulate ideas... What can be more worthy? And what can give greater joy of life? I have lived my life, and I can say: neither money, nor power, nor even love (I do not even speak about wine and drugs) can give you the wonderful, keen feeling that embrace a person when the heap of discrepant and seemingly unrelated facts suddenly find just proportion, simplicity, and you begin feeling harmony of the universe. I believe that something like this is felt by a woman who keeps healthy and crying baby against her breast after a long and difficult pregnancy and childbirth. Creative work is the only way for a person to experience this feeling.

But my words are also for venerable scientists of my own generation. You are knowledge curators. It is impossible without you to create hierarchy, canon so important for the science of the coming millennium, so necessary to construct "Beads game" on the place where today we observe a mixture of strange fantasies called physical concepts. So let us not become like politicians who put their personal ambitions higher than the interests of our common pursuit. In the great evolution movement the Lord prescribed to us the role of the humanity brain. So let us be worthy of our destination.

I take this opportunity to express my gratitude to everybody who directly or indirectly helped in my difficult journey to modern physics. And first of my thanks are addressed to I.V. Prohorzev. This book could not have appeared at all without his attention and support. I am very grateful to all my colleagues in the St. Petersburg Physical Society seminar, and first of all to the seminar curator A.P. Smirnov, and to the 'first between equals', V.A. Fogel, who attracted my attention to electrodynamics and persistently revived that interest, sometimes even despite my resistance.

As always professional was Svetlana Begacheva who typeset the earlier Russian edition of this book. As always forbearing and benevolent was my wife, Alena, about my love to whom I would like to speak here because I seldom pronounce this in everyday life. My thanks to my teachers – professors of Leningrad State University who has given the habit for quantitative investigations and perhaps naive believe in the final victory of truth to me, also to all my friends, and first of all to A.N. Proszenko who always found strength to support me in my foolhardy initiatives.

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FOREWORD

I believe that Physics is presently in an unrecognized crisis. The problem begins early in the twentieth century, with the advent of Special Relativity Theory (SRT). At that time, there was a great deal of confusion and uncertainty, and Einstein sought to cut through it all by starting a new mathematical analysis based on clearly stated new Postulates concerning the propagation of light. Signals. His new First Postulate was that the laws of Nature should be the same for all observes in all inertial reference frames, and his new Second Postulate was that the speed of light should be the same for all observers in all inertial reference frames.

Einstein's first Postulate seems reasonably unobjectionable, although one could quibble a little bit that observers in inertial reference frames do not actually exist, inasmuch as all real observers have mass, and their instruments have mass, sometimes quite a lot of mass, so any reference frame in which observers and their instruments reside is not really inertial. So one has to think of the word 'inertial' as being to Physics what the words 'infinitesimal' and 'infinite' are to Mathematics: limits that one can talk about, but not actual physical states about which one can do experiments.

Einstein's Second Postulate seems potentially more objec-tionable. The problem there is that the little word 'in'. It really means the big word 'throughout'. The speed of light is pre-sumed to have the same reference over the entire propagation path. That is, c is c relative to the receiver of the light, not just at or near the receiver, but all the way back to the source. You can tell that this is the meaning by looking at the subsequent math expressions. Everywhere you see $1/c$. The c is clearly meant to meant to be a constant throughout the problem domain. There is nothing to indicate any variation, even in reference, for c. It is a constant throughout the coordinate frame in which the particular problem is presented.

This Second Postulate is very bold indeed. Compare it to the more typical sort of statement used for a math problem. Typically, there are differential equations, and one or more families of solutions, and some boundary conditions. But this Second Postulate is not a boundary condition. Instead, it is a whole space commandment. It is likely to constitute an over-constraint. So it is likely to cause conflicts and Paradoxes.

Paradoxes: those seem to be what SRT is most loved for! In the ancient world, and even in the pre-Einstein modern world, mathematicians worked hard to avoid Paradoxes. The goal was to develop ideas upon which different people could agree. The belief was that people could arrive at a shared vision of Reality.

The word 'Relativity' sounds very close to the word 'Reality', but actually it is not conceptually close at all! In embracing Relativity, we inevitably renounce the notion of shared Reality.

One way to restore Reality would be to find some kind of experimental evidence that something is not right with SRT. Many experimenters have applied their talent to this task. This book takes note of such individuals and celebrates their efforts.

Electrodynamics is the main area in which the experimenters have worked. And so the book begins with Electrodynamics. A few of the people involved have been recent enough that Klyushin and/or I have known them personally. Heroes all!

One thing leads to another. Electrodynamics involves signals of attractive nature, and so does gravity. So whatever imperfections we have had in our understanding of light signals very likely afflicts our understanding of gravitational signals as well. So the book proceeds to Gravidynamics.

And then there is Thermodynamics. I am especially fond of Statistical Mechanics and Statistical Communication Theory, both of which employ Entropy, the child of Thermodynamics, as their explanatory core.

Then we have Elementary Particles. There are so many that it seems ludicrous to call them elementary. But maybe a less perverse formulation of SRT could bring more order.

Finally, there is Aether. With SRT, we sent Aether to Purga-tory. But do we need Aether after all? Until SRT banished it, Aether was imagined as a candidate reference for light speed. We still seem to need something for that job. Alternatively, if we would just clean up SRT, we would always have two boundaries, Source and Receiver, and we wouldn't need the name Aether, as such, for any un-manned job.

To be fair about SRT: It was a very good idea to organize the thought process into formal Postulates. But it was not a good idea to state the Postulates so very briefly, and especially not a good idea to leave unclear how very strong the Second Postulate really was, and maybe how over-constraining it was, and how that would affect whatever problems would be at hand to solve.

March, 2019

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INTRODUCTION

All of the sciences can be divided into two classes: sciences "long" and sciences "wide". Mathematics is an example of a "long" science: it constructs long chains from initial axioms-assumptions and to conclusions. Examples of "wide" science are provided by History and Economics. In these sciences, there exist a lot of different and not clearly related facts, from which small "pig tails" (conclusions) emerge.

In accord with widely spread opinion, Physics is a "long" science: just see how many facts follow from it. But more attentive analysis shows that in this respect modern Physics is much closer to Economics than to Mathematics. Multiplicity and semantic confusion of what appear to be fundamental terms, use of mathematics, not to clear up, but rather to obscure, the essence of the problems, citation of authority as a proof – all these are birth-marks of wide sciences, and are also characteristics of Physics nowadays. The author is sure that modern Physics is in crisis – a crisis more profound even than a hundred years ago. One can call it the "lengthening" crisis.

This situation in Physics means that it is useful to look at how other sciences, and especially the first-of-all pattern for other sciences, Mathematics, have passed through such times of crisis. One can say that the last crisis of mathematics began from realization of the problem of Euclid's fifth postulate in the second half of the XIX^th^ century, and ended in the beginning of XX^th^ century by formulation of the "axiomatic method" in mathematics.

And what was realized in this Mathematics crisis process? First of all it was realized that it was impossible to define everything with the help of everything. Some notions should be given to the scientist's intuition. For instance, the notion of "set" is not defined in mathematics, but there exists a set theory. But there should not be too many such non-defined notions. Otherwise, different persons may have different understanding of the same assertion. Later on, construction of new theory must begin with formulation of axioms. These axioms are not compelled to be "self-evident truth". The set of axioms certainly must satisfy some demands of non-contradiction and completeness, *etc*. But these assumptions can be absolutely free in other senses.

What can Physics of new millennium take from this mathematical tradition? I believe first of all that it is necessity to essentially decrease the number of non-defined notions. Nowadays there are tens, if not hundreds, of such notions in Physics. Conservation of energy is enunciated as a "principle", but nobody knows what energy is. They write textbooks on field theory, but nobody knows the field's definition. They call "equation" everything where an equality sign appears, although half of these "equations" are really identities and definitions.

One example follows. Apparently the first one who spoke about this was Lagrange. Kirchhoff was the first one who put the question point-blank. The reasoning of A. Poincare in his "Lectures on Mechanics" [1] is reproduced below, in a slightly free manner perhaps. Poincare wrote approximately the following: In what case may the correlation $\mathbf{F} = m\mathbf{a}$ is called a law? Only if we have three independent definitions: force $\mathbf{F}$, mass m and acceleration $\mathbf{a}$. Only after this can a clever man after sitting under apple or plane tree come to us and say: "All of you old chaps thought that these things are not connected with each other and I tell you there is the equality here, let us come to experiments".

But the situation is actually quite different. In a pinch we can say that we understand what $\mathbf{a}$ is, if we understand what space and time are. Then Poincare shows that all mass definitions he knows are flawed in this or that aspect. And already completely, – Poincare goes on, – we do not understand what force is. The conclusion: the assertion we call the second law of Newton is definition at best: if mass velocity changes as a result of external causes and the mass is accelerated we assert that a force acts on the mass.

But let us turn further the pages of physical textbooks. We see the very mass in gravitational field with potential Φ. A new definition appears: force $\mathbf{F} = m\nabla\Phi$. Technically, these definitions are completely different. Are the definitions equivalent, or do they differ in some aspects? We shall consider Lorentz and Weber forces in electrodynamics below. How are these concepts linked with the one mentioned above? I have not found an answer in the textbooks I know.

The following passages are typical in modern textbooks. A long discussion takes place concerning electromagnetic forces acting on an electron. Then they remember: ah but the force is the impulse time derivative, let us equalize these concepts. And why is the force not potential gradient? And who has given us right to equalize things of different origin? And who said to us that electrically charged body reaction to the force is the same as of electrically neutral? As a minimum, the validity such assertions must be grounded for a long time. But any consequence can follow from a false premise. Therefore, they sometimes come to valid conclusions.

But let us return to the Physics crisis. What seems to be the first and most important step? It is to enumerate and minimize the number of non-defined notions. Perhaps we should limit ourselves to the intuitively clear concepts of space, time, mass… Perhaps 3 or 4 notions in addition are needed. I am afraid that many spades will be broken in this battle. Because one of the greatest losses Relativity Theory inflicted upon physics is the habit to behave in a familiar way with notions of space and time: to mix them up with corresponding concepts in mathematics. Metric, topology for a mathematician is just a convenient way for him to build his logical construction. He attaches no physical meaning to them. Although physical space and time in which we live may be supplied with some qualities of mathematical metric, actually it is linked with no logic definitions. This is something given us by the Lord who also supplied us with the capability to orientate ourselves. Meanwhile there are amateurs proposing to consider physical space as a general topological space, and even a fiber space.

Thus the first task is to select and reach common understanding of fundamental notions in physics. The second

step would be formulation of main postulates. Certainly desires for mathematical axioms are not sufficient for physical postulates. We must demand that the corollaries of axioms be corroborated by experiments. The problem of what experiment is correct, and above all what its interpretation is, certainly will need long discussions.

Here we only note that capability for a theory to explain an experiment cannot yet be the ground to proclaim the theory correct. For almost two millennia, Ptolemy's astronomy and Aristotle's belief that movement with constant speed must be maintained by external force were confirmed by experiments. But nowadays we do not believe in that. For almost a century, some experiments were considered to be confirmation of Special Relativity theory. Nowadays they found explanation within the framework of other theories that explain dozens of other facts that cannot be explained in the framework of SRT, and up until recently were explained either *ad hoc* or were not explained at all.

It seems that the English root in modern physics proclaiming primacy of experiments prevails also in the current science, and suppresses the French root demanding transparent logic and elegant theory construction. The future for physics apparently lies in the prospect of somehow harmonizing these principles.

And what should the physical axioms look like? Apparently, the equations of fundamental fields must become such axioms. There has already being been such a tradition in physics. But today the theorems, *i.e.,* the corollaries, the consequences from the equations are constructed completely unsatisfactorily using vague and previously non-defined notions. Therefore it seems that physics development during the near future years must look as follows. Fundamental filed equations are written, for instance equations of electrodynamic, gravidynamic, or thermodynamic fields. All the consequences from these equations are looked over. It is ascertained why some facts cannot be understood as consequences from the equations. After that, either initial equations are generalized or new postulates are introduced.

CHAPTER 1: ELECTRODYNAMICS

1. Preface to Chapter 1

Electricity and everything connected with it is the most important part in modern physics. Its experimental base and theory are considered a pattern for the other section of physics.

But the experiments of G.V. Nikolaev [38] and Graneau [39] and many others show that an essential part of electrodynamic effects is not covered by today theory. But such experimental facts are not verified and rejected by official science. We can assert this not only about experiments set today but also about experiments put by electrodynamics fathers Ampere, Weber and Gauss. Their experiments perhaps have become a sacrifice of discussions between supporters and opponents of the long-range and close-range theories. Field theory victory has brought not only success in some aspects but also oblivion of some ideas of our scientific grandfathers. See real problem are solved with the help of formulas for charges' interaction force. Therefore 90% effects of Maxwell equations are lost if Lorentz force formula is used. It is lost because Grassmann's equations are not necessary and which needs only the charges' characteristics. Already Maxwell notes that Grassmann's formula is a term in the Ampere one. The very Ampere formula is an item in the generalized electrodynamics considered below.

The second problem of today electrodynamics as just thermodynamics as well is absence of natural formula connections with other part of physics and especially with the "mother of all sciences" classic mechanics. The reason is simple: these parts use different languages to describe similar and sometimes even identical problems. Introduction of common language for different parts of physics would greatly facilitate of successful methods of work from one part of physics to another one and clear the essence of the problems. This author widely uses mechanic dimension in electrodynamics and thermodynamics and it greatly helps me in my work and understanding of the problems from different parts of physics. I am sure that the reader who find time to reformulate his investigations in mechanic dimension would understand the feeling of working with "clarified optics". Therefore perhaps it is more useful to begin reading not with generalized electrodynamics but with mechanic dimensions in electrodynamics (§3).

2. Some Fundamental Problems in Electrodynamics

2.1. Historical Review of Electrodynamics Theories

Electrodynamics is considered to be truly a fine example for the other branches of physics, as far as its logical aspects, as well as its experimental proof are concerned. Houses are lit by the bulbs; electric power stations work; we communicate by means of Internet. What more can there be?

However, if we make a more detailed examination, we will find out that everything is all right only in some special cases, like parallel wires with electric current. And yet, the present explanation of induction raises a number of objections, which we shall only mention here. Doctorovich [2] documents the more detailed considerations.

A great many, or even all, problems in electrodynamics arise from the fact that in modern terms the theory was formulated as a result of sometimes very different approaches to the description of phenomena. Those approaches were consequently being matched to each other without a unifying train of a thought. The logical flaws were exacerbated by artificial, sometimes apparently non-symmetric, definitions.

Let us mention here the basic stages of formation of electrodynamics, which are usually rendered in present-day university courses. The attraction of electrified objects, experimentally known since the ancient times, was formulated in terms of rigid mathematical definition, known as Coulomb's law: the force of interaction of two electric charges q_1 and q_2

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}. \qquad (2.1.1)$$

Let us investigate this formula. What does it say? First of all, the force $\mathbf{F}_{21}$ is a vector, and (2.1.1) points out the direction of this force: the force is radial and directed along the radius going from charge 2 to charge 1. Its proportionality to the radius vector $\mathbf{r}_{21}$, going from charge 2 to charge 1 accounts for the directionality. Value r, the modulus of radius vector $\mathbf{r}_{21}$, is in the denominator of the fraction.

We will further use the Descartes' three-dimensional rectangular system of coordinates, points of which will be denoted as $x(x_1, x_2, x_3)$, t be time and $\mathbf{i}, \mathbf{j}, \mathbf{k}$ be unit vectors. So, we have the following (in Descartes' rectangular three-dimensional coordinate system):

$$\mathbf{r}_{21} = ((x_1^1 - x_1^2),(x_2^1 - x_2^2),(x_3^1 - x_3^2)), \qquad (2.1.2)$$

$$r = \sqrt{(x_1^1 - x_1^2)^2 + (x_2^1 - x_2^2)^2 + (x_3^1 - x_3^2)^2}. \qquad (2.1.3)$$

The upper indices denote numbers of the charges. So, for example, $(x_1^1 - x_1^2)$ means the distance between the charge 1 and charge 2 along the axis x_1. It is supposed here that the size of charges is negligible in comparison with r. If it is not mentioned to be untrue, we will suppose it to be true, below. The formula (2.1.1) contains a radius, as the vector, which stands in the numerator, and the third power of its scalar value, which stands in the denominator. This means that the value of a force decreases as the square of a distance.

Some more values, besides the distance, appear in (2.1.1). First of all, these are the charges q_1 and q_2. The modern manuals consider the conception of any electric charge as some primary essence. We will return in Appendix 1 to the question of the physical meaning of the charge. Here we will follow this traditional point of view, mentioning only the fact that in the SI-

system, which we will apply, the unit of the charge is Coulomb. And, even now, we encounter some problem making a correct definition.

The next approach would be natural. Of course, we do not understand the exact meaning of the conception "charge", but we are sure, that there are particles, carrying minimum quantity of this quality. So, one can assume the charge of electron, proton, or some quantity of these charges, to be equal to a unit charge, for example $6.25\times10^{18}\,e$, where e means a charge of electron. One usually proceeds this way. But at the same time, one does not determine the unit of a charge, which is equal to the previously written number of elementary charges, and called "Coulomb" (in SI-system). Instead, at the beginning the speed of changing of the charge e "Coulomb per second" is defined. This value is called the "Ampere", and it is defined as a force of constant current, if it goes through a pair of parallel straight conductors of infinite length and infinitesimally small cross-section, provided the distance between the conductors placed in vacuum equals 1m, so the current induces the force between these conductors, which is equal to 2×10^{-7} Newton per meter.

What is interesting here for our discussion? One wants to determine the unit of a charge and the force of current in terms of force, but not *vice versa*: such-and-such force corresponds to such-and-such quantity of resting or moving charges. Such inconsistent determinations seem to be natural from the historical point of view.

As a matter of fact, even now, all the electrical devices that measure electrodynamic characteristics measure the force, or angular momentum of the force. We will mention, before coming to the discussion of the main stages of the development of electrodynamics, that there is one more value present in (2.1.1); namely, ε_0. This constant is usually called the "electric constant" or "permittivity" of free space. It characterizes interaction of charges in vacuum. It can be measured experimentally:

$$\varepsilon_0 = \frac{1}{4\pi\cdot 9\times10^9}\ \mathrm{C^2N^{-1}m^{-2}}. \qquad (2.1.4)$$

This constant indicates that the force of interacting charges is not equal to, and only proportional to, the product of charges, as well as inversely proportional to the square of distance. This constant arises only in SI-system. If one changes the value and dimension of an electric charge, the constant can be equal to unity, which happens in CGSE-system. Although, it is convenient sometimes for calculation process, we will see that it obscures very much the physical meaning of electrodynamic expressions, whereas ε_0 has a fundamental mechanical meaning of free ether mass density (§3, 10).

So, in the middle of the 40th of the XIX century, physics knew two fundamental laws: the law of gravitation and the Coulomb's law. Both laws predicted the existence of radial force of interaction between two charges, the magnitude of which decreases as the square of distance.

In 1846, Wilhelm Weber offered the generalization of Coulomb's law for the case of moving charges, when the passive charge equals unity. Weber probably took the value of the passive charge equal to unity just as a matter of convenience. Nevertheless, as we will see later, this inconspicuous simplification stemmed up a certain ideology, which is natural for modern manuals on physics. As a matter of fact, it brought to simplistic understanding of the notion of "electric field", as a force, which acts on the test charge. Let us start from the very beginning.

The Weber's formula for the case of two charges is:

$$\mathbf{F}_{21} = \frac{q_1q_2\mathbf{r}_{21}}{4\pi\varepsilon_0 r^3} - \frac{q_1q_2\mathbf{r}_{21}}{8\pi\varepsilon_0 r^3c^2}\left(\frac{dr}{dt}\right)^2 + \frac{q_1q_2\mathbf{r}_{21}}{4\pi\varepsilon_0 r^2c^2}\left(\frac{d^2r}{dt^2}\right). \qquad (2.1.5)$$

Let us summarize what is said above:

1. The force (2.1.5) is radial. It is clear psychologically because all of the fundamental forces that were known at that time were radial. It is widely adopted that radial character of force is the condition for the third Newton's law condition validness. We assert that this is not so. We shall return to this problem in section 10.

2. The force, which was added to the Coulomb's force, depends on the relative velocities and accelerations of the charges; that is, formula (2.1.5) predict the presence of a force in addition to Coulomb's force, even if one of the charges (for example the "test charge" 1) is at rest.

3. Formula (2.1.5) satisfies Newton's third law: the force with which charge 2 acts on the charge 1 is of magnitude equal to and direction opposite to the force with which the charge 1 acts on charge 2. Both forces are directed along the same straight line.

4. Formula (2.1.5) accounts for interaction of charges, saying nothing about the mechanism of propagation of such interaction in space.

The last statement made physicists at the middle of the former century feel rather ambivalent, because interaction had "contact character" in mechanics – the queen of science in that day. This statement is a matter of discussion for scientists nowadays though.

In 1782, in order to overcome difficulties of long-range interaction, Laplace suggested replacing gravitation law with the differential equation for some parameter, named the "field". Under such an approach, one can consider that the differential equation describes the short distance interaction between the neighboring elements of the field.

The introduction of this field substitutes the problem of "long-range" interaction between the real charges by the problem of "short-range" interaction between the neighboring regions of space, which is filled in with some artificially invented field. We are obliged to Laplace for the idea of introducing the equations of the field – equations that act everywhere outside the points at which the charges are placed.

Maxwell suggested his famous system of equations for electromagnetic field, having used the idea of field for the problems of electrodynamics and generalizing the results of experiments, accomplished first of all by Faraday in terms of the field. Let's write the equations. We shall do this one Heaviside's interpretation which had become traditional in the XXth century. Let us stress that the very Maxwell used total time derivatives in these equations although this is not widely known ([4], section 598).

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}, \tag{2.1.6}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \tag{2.1.7}$$

$$\nabla \cdot \mathbf{B} = 0, \tag{2.1.8}$$

$$c^2 \nabla \times \mathbf{B} = \frac{\mathbf{j}}{\varepsilon_0} + \frac{\partial \mathbf{E}}{\partial t}. \tag{2.1.9}$$

Here $\mathbf{E}$ and $\mathbf{B}$ are fields called electric and magnetic ones, ρ is electric charges' density, $\mathbf{j} = \rho\mathbf{v}$ is electric current density, *i.e.,* the charges' density propagation with velocity $\mathbf{v}$, ε_0 is previously mentioned electric constant. It will be shown that ε_0 means free ether density. But what is the physical meaning of the $\mathbf{E}$ and $\mathbf{B}$ fields?

A partial answer is obtained when (2.1.6) is integrated under condition

$$\nabla \times \mathbf{E} = 0. \tag{2.1.7a}$$

One obtains having integrated (2.1.6)

$$\mathbf{E} = \frac{q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}, \tag{2.1.10}$$

where q_2 is the charge quantity in the integration volume and $\mathbf{r}$ is radius-vector from charge 2 to the observation point.

This correlation is very similar to Coulomb's law (2.1.1). It is just supposed in Coulomb law that charge q_1 is situated in the observation point. We shall obtain force from (2.1.10) if multiply it by charge q_1, *i.e.*, $\mathbf{E}q_1$ is the force with which static charge q_2 acts on static charge q_1.

But Eqs. (2.1.6)–(2.1.9) contain in addition the magnetic field $\mathbf{B}$ which must also somehow influence on the test charge q_1. Apparently, Heaviside was the first person to propose the formula later called Lorentz force. Here is the force:

$$\mathbf{F}_{21} = q_1\mathbf{E}_2 + (q_1\mathbf{v}_1 \times \mathbf{B}_2), \tag{2.1.11}$$

with which moving charge q_2 is said to act on moving charge q_1. Here test charge q_1 appears explicitly. The charge q_2 action is concealed in the fields $\mathbf{E}_2$ and $\mathbf{B}_2$ that it creates.

What do these fields look like? In order to answer this question we must solve equations (2.1.6)–(2.1.9) for q_2 and substitute these solutions into (2.1.11). But we do not know Maxwell's system solution for separate charges. We can find them in some special partial cases. One of such cases is the case of long beam of moving electrons. In this case

$$\mathbf{B}_2 = \frac{\mathbf{I}_2 \times \mathbf{r}_{21}}{2\pi\varepsilon_0 c^2 r^2}, \tag{2.1.12}$$

where $\mathbf{I}_2$ is current, *i.e.,* the charge quantity intersecting the beam transverse section per second, c is light speed. Eq. (2.1.12) may be transformed if the charges' velocity in the beam $\mathbf{v}_2$ is written explicitly.

$$\mathbf{B}_2 = \frac{\lambda_2(\mathbf{v}_2 \times \mathbf{r}_{21})}{2\pi\varepsilon_0 c^2 r^2}. \tag{2.1.13}$$

Here λ_2 is linear charge density in the beam. Eq. (2.1.11) for this case looks as follows:

$$\mathbf{F}_{21} = \frac{q_1\lambda_2\mathbf{r}_{21}}{2\pi\varepsilon_0 r^2} + \frac{q_1\lambda_2}{2\pi\varepsilon_0 r^2 c^2}\left[\mathbf{v}_1 \times (\mathbf{v}_2 \times \mathbf{r}_{21})\right] = \frac{q_1\lambda_2\mathbf{r}_{21}}{2\pi\varepsilon_0 r^2} + \frac{q_1\lambda_2}{2\pi\varepsilon_0 c^2 r^2}\left[\mathbf{v}_2(\mathbf{r}_{21}\cdot\mathbf{v}_1) - \mathbf{r}_{21}(\mathbf{v}_1\cdot\mathbf{v}_2)\right]. \tag{2.1.14}$$

Let us compare this formula with the Weber's (2.1.5).

1. Force (2.1.14) has not only force directed along the radius $\mathbf{r}_{21}$, but also force directed along the velocity $\mathbf{v}_2$.

2. The radial force additional to Coulomb's force depends on the velocity product $\mathbf{v}_1\cdot\mathbf{v}_2$. Therefore it is zero if at least one charge is at rest. This conclusion compels modern physics, which limits itself with this formula, and asserts that only Coulomb force acts between a moving charge and a charge at rest, even though simple experiments show the invalidity of such an assertion.

3. Eq. (2.1.14) does not satisfy Newton's third law. If for instance $\mathbf{r}_{21}\|\mathbf{v}_1$, $\mathbf{r}_{21}\perp\mathbf{v}_2$, $\mathbf{v}_1\perp\mathbf{v}_2$, *i.e.*, $\mathbf{v}_2(\mathbf{r}_{21}\cdot\mathbf{v}_1) \neq 0$, $\mathbf{r}_{21}(\mathbf{v}_1\cdot\mathbf{v}_2) = 0$, then changing indices we obtain expression for the reaction force: $\mathbf{v}_1(\mathbf{r}_{12}\cdot\mathbf{v}_2) = 0$, $\mathbf{r}_{12}(\mathbf{v}_1\cdot\mathbf{v}_2) = 0$, *i.e.*, in this case the action force is non-zero and the reaction force is zero.

4. The interaction between charges in (2.1.11) is explained in terms of the fields $\mathbf{E}_2$ and $\mathbf{B}_2$ that charge q_2 creates in the surrounding space. For all this $\mathbf{E}_2$ acts on the "static part" of the test charge, and $\mathbf{B}_2$ acts on the component depending on the test charge velocity. Let us note that this means that the test charge is as if it does not have fields of its own. The external fields act directly on it. But this short-range action disappears in formula (2.1.14), which is equivalent to (2.1.11). In other words, a question appears: isn't it our wrong intuition that leads us to the problem of long- and short-range action?

5. Eq. (2.1.14) does not predict a force induced by the charge's acceleration, but the Eq. (2.1.5) force depends upon it.

Let us repeat once more that the very idea of formula (2.1.14) is to find interaction force knowing the fields created by charge q_2 and the characteristics of the charge q_1.

But the problems with finding solutions to the Maxwell to the system made it necessary to reverse the situation. There is a characteristic example in the textbook by Prof. E.M. Purcell ([5], p. 182). Having written our equation (2.1.11) he writes: "…we accept it (formula (2.1.11)) as a definition of Electric and Magnetic field in this space point."

In other words, we are proposed, not interaction force to define with the help of the fields (the idea initially incorporated into the formula), but rather, having adopted the formula to be universal and exhaustive, to define fields with the help of measured force. But such an attempt meets many problems. Let us pin-point some of them.

Generally speaking, four unknown variables appear in formula (2.1.11):

1. The first two are the value and velocity of the test charge. Usually (but not always) the way out is found accepting that test charge is unit and the velocity is known.

2. The second two are fields $\mathbf{E}_2$ and $\mathbf{B}_2$ created by charge q_2.

Purcell writes further: "We have proved that the force acting on the test charge is completely independent with respect to its velocity if the other charges are at rest. This means that Eq. (2.1.11) is valid everywhere that $\mathbf{B}_2 = 0$".

But even if we accept the proof, which is very non-evident because it incorporates many unnatural assumptions, the problem is that Eq. (2.1.11) must be valid also in the case when $\mathbf{B}_2 \neq 0$, because $\mathbf{E}_2$ changes as well when $\mathbf{B}_2$ changes. But in accord with the idea of Purcell himself, immobility of the charge q_2, *i.e.,* condition $\mathbf{B}_2 = 0$, is a necessary condition for the validity of the first item.

But perhaps the greatest problem is that formula (2.1.11) is not universal. Therefore we lose many very important partial cases incorporated into Maxwell equations if we define the field with the help of (2.1.11).

In practice, this means that $\mathbf{E}_2$ is understood as the charge q_2 static field (the dynamic part of $\mathbf{E}_2$ is lost); *i.e.,* the special case (2.1.7*a*), but not general case (2.1.7), is considered.

Thus the Lorentz force formula cannot replace Maxwell equations and asymmetric definitions proposed in text-books cannot describe Electric and Magnetic fields which we must obtain as solutions of the Maxwell system. Therefore they often strive to obtain force manipulating with (2.1.6)–(2.1.9) equations in particular integrating them over volumes or surfaces. But let us try to understand the mathematical meaning of the system (2.1.6)–(2.1.9).

If these are the equations, then what do they determine? It is usually assumed that charge and current densities are known. The answer looks evident: this is equation system in which $\mathbf{E}$ and $\mathbf{B}$ are unknown. But in order to find two vector-functions we need two vector equations [(2.1.7) and (2.1.9)], not more, and not less. But system (2.1.6)–(2.1.9) incorporates two scalar equations in addition. Does this mean that the system (2.1.6)–(2.1.9) is over determined?

It is strange, but the only book in which I found a certain perplexity inspired by this fact is the magnificent monograph on continuous media mechanics by L.I. Sedov [6]. In all other books I read, including books written by mathematicians, such a strange fact astonishes nobody. Rushing a little bit forward, one can say that when system (2.1.6)–(2.1.9) is generalized it becomes clear that the equations, *i.e.,* equalities valid only with some values of the unknown variables, are vector correlations (2.1.7) and (2.1.9). Equalities (2.1.6) and (2.1.8) define initial conditions, *i.e.,* they are definitions or identities.

Apparently two different points of view are acceptable in when we consider (2.1.6) and (2.1.8) equities.

The first is that they determine initial data. It will be shown in §3 electric values can't be expressed in mechanic terms (dimensions).

Thus (2.1.6) just characterizes electric charge distribution in the initial time. (2.1.8) equality just describes the supposition of magnetic charge absence. We shall return to this problem in the next part of this paragraph.

The second approach arises from Helmholtz theorem that any "reasonable" field is at sum of its divergent and curl parts. Thus we can believe that (2.1.6) and (2.1.8) define the divergent part of the solution and (2.1.7) and (2.1.9) define its curl part. This point seems as more general as more natural. It is more general because it pin points one limitation of today approach: (2.1.6) supposes stability of the electric charge distribution, its static character.

Just because of this we can obtain Coulomb law from (2.1.6). But system (2.1.6)–(2.1.9) cannot describe the field created by pulsating charge for instance. The dynamic approach would yield changing the equity (2.1.6) for an equation in which the right part (charge) depends on time. We shall restrain with the first point of view in this investigation.

Let us note that accurate following of this understanding meets a certain problem: the right hand part of the divergent correlations must describe the process of "charge generation" by ether particles. Mathematically, this means that angular velocity of the ether particles must appear there.

We tried to construct such a theory in section 6. This led to a necessity to describe fields in terms of complex functions. The field energy turned out to be equally distributed between real and imaginary parts of the field. In particular, just because of this elementary particles energy is equal mc^2 and not $\frac{1}{2}mc^2$. Some other useful results were obtained, and I am sure others can be obtained in addition. But this needs quite a new theory.

Here we limit ourselves with only real functions. Therefore the following interpretation of (2.1.6)–(2.1.9) is possible here. In accordance with the well-known theorem by Helmholtz, any field consists of a divergent part and a curl part. Thus scalar correlations (2.1.6), (2.1.8) define the divergent part, and (2.1.7), (2.1.9) define the curl part. But purely a mathematical problem appears here: how to find a vector function with the help of a scalar equation.

Actually we have got the vector function (2.1.10) from the scalar correlation (2.1.6) with the help of mathematical forgery. We cannot do this strictly logically. Physical textbooks obtain this result "repeating some physical words". We are not going to devote too much space to this problem here. But, dear reader, try to calculate the divergence of the vector function (2.1.10) in order to evaluate reliability of such "physical words" in general. Have you got zero? But let us return to our narration.

Historically, many formulas for interaction force between charges were proposed as generalizations of some experimental facts, without any concept of field. One of them, the Weber one, was mentioned above. Weber's formula (2.1.5) depends on relative velocities and accelerations of the charges. Formulas depending on the product of absolute velocities of the charges were also proposed. All of them were based on experiments with currents in neutral conductors and formulated in terms of current differentials. For reference, we reproduce them below in terms of separate charges and their velocities, which will be used in Section 2.

Neumann formula [7]:

$$\mathbf{F}_{21} = +\frac{q_1 q_2}{4\pi\varepsilon_0 c^2 r^3}\mathbf{r}_{21}(\mathbf{v}_1 \cdot \mathbf{v}_2). \tag{2.1.14a}$$

Grassmann formula [8]:

$$\mathbf{F}_{21} = -\frac{q_1 q_2}{4\pi\varepsilon_0 c^2 r^3}\left[\mathbf{v}_2(\mathbf{r}_{21} \cdot \mathbf{v}_1) - \mathbf{r}_{21}(\mathbf{v}_1 \cdot \mathbf{v}_2)\right]. \tag{2.1.14b}$$

Ampere formula [9]:

$$\mathbf{F}_{21} = -\frac{q_1 q_2}{4\pi\varepsilon_0 c^2 r^5}\Big[3(\mathbf{r}_{21}\cdot\mathbf{v}_1)\cdot(\mathbf{r}_{21}\cdot\mathbf{v}_2) - 2(\mathbf{v}_1\cdot\mathbf{v}_2)r^2\Big]\mathbf{r}_{21}. \tag{2.1.14c}$$

Whittaker formula [10]:

$$\mathbf{F}_{21} = -\frac{q_1 q_2}{4\pi\varepsilon_0 c^2 r^3}\Big[\mathbf{v}_1(\mathbf{r}_{21}\cdot\mathbf{v}_2) + \mathbf{v}_2(\mathbf{r}_{21}\cdot\mathbf{v}_1) - \mathbf{r}_{21}(\mathbf{v}_1\cdot\mathbf{v}_2)\Big]. \tag{2.1.14d}$$

But let us return to the problem of how system (2.1.6)–(2.1.9) is used, and for explanation of what phenomena. Eq. (2.1.7) is usually used to explain induction. Its integral form is often used:

$$\int_L \mathbf{E}dl = -\frac{\partial}{\partial t}\iint_S \mathbf{B}ds. \tag{2.1.7b}$$

Here L is a certain closed contour, and S is an arbitrary surface bounded by L.

To my regret, we are compelled to concentrate on the mathematical side of integral transformations. In order not to burden our conversation with distracting details, we shall not consider formulas for spatial integrals; they can be found in any textbook on mathematical analyses and physics. But we must pay attention to some peculiarities of differential and integral transformation. We must remember that we have no right to differentiate or integrate equations under equivalent transformations. For instance equation $2x + 1 = 0$ is the derivative of the equation $x^2 + x + 5 = 0$. But not many physicists would dare say that they are equivalent.

We have right to differentiate and integrate such equations only when we substituted solutions in them, *i.e.,* converted them into identities. Therefore we do not need any additional suppositions in order to come from (2.1.6) to (2.1.10). But in order to come from (2.1.7) to (2.1.7*b*), we are compelled to suppose that already solutions of the system (2.1.6)–(2.1.9) figure in (2.1.7*b*). For better understanding, **E** and **B** in (2.1.7*b*) should be marked somehow to emphasize that they are already-known functions, in contrast to **E** and **B** in (2.1.7), which are unknown, and must be found.

This is said in order to stress that **E** and **B** in (2.1.7*b*) are certain functions determined by charge density ρ and current density **j**. The problem of how other charges react on such fields must be solved by some additional axiom; for instance, the Lorentz force formula. We shall see that this formula is not universal enough, and it must be generalized, but in principle it plays role of such an axiom that defines the rule of interaction between the fields induced by two different charges. But the Lorentz force formula does not cover some important cases. Therefore the idea has appeared to describe interaction between two charges with the help of so called "flow rule".

That very rule is described in every textbook. We shall not spare time for it. It appeared as an attempt to describe the case when a loop moves in constant magnetic field or is at rest in alternating one.

The left hand part of equality (2.1.7*b*) is believed to be determined by the charges in the loop, and the right hand part by the external charges, creating external magnetic field.

Let us repeat once more: such a partition of the fields contradicts the essence of equality (2.1.7*b*), which actually just informs us about identity of the electric field circulation and time derivative of the magnetic field flow, created by the same charge distribution.

The Lorentz force formula (2.1.11) works correctly when the current loop moves in constant magnetic field. But it fails to describe the effect observed when current loop is at rest in an alternative magnetic field. To explain just this case equality (2.1.7*b*) was used. It helped to obtain the necessary result, and logical jumps on this way were not noticed. But not by all; some felt certain discomfort here. Let us cite the corresponding discourse by R. Feynman [11, p.53]: "The two possibilities – "circuit moves" or "field changes" are not distinguished in the statement of the rules. Yet in our explanation of the rule we have used two completely distinct laws for the two cases: $\mathbf{v}\times\mathbf{B}$ for "circuit moves" and $\nabla\times\mathbf{E} = -\partial\mathbf{B}/\partial t$ for "field changes". "We know of no other place in physics where such a simple and accurate general principle requires for its real understanding an analysis in terms of two different phenomena. Usually such a beautiful generalization is found to stem from a single deep underlying principle. Nevertheless, in this case there does not appear to be any profound implication. We have to understand the rules as the combined effects of two quite separate phenomena."

No, Mr. Feynman, we should not combine two separate phenomena; we had better use the generalized Lorentz force formula, which will appear in this book, Section 2, because the phenomena are really different.

But why does correlation (2.1.7*b*) in modern-day interpretation so luckily bridge the gaps in Lorentz force formula (2.1.11)? We shall see below that generalized Lorentz force formula in the case of changing fields comes to very similar correlation, but for two different charge distributions; *i.e.,* **E** in the left hand part of (2.1.7*b*) is determined by one distribution and **B** in the right hand part by another one.

Not aiming to investigate the problem of the Poynting vector, let us mention it as an example of a symmetric logical mistake. The Lorentz force formula is used to deduce Poynting formula [11, p. 289]. We have already said that this formula describes interaction of the fields originated by two different charges distributions. But these fields are identified when the Poynting formula is obtained; therefore, using the Poynting vector sometimes leads us to very strange conclusions.

The Poynting vector was introduced to describe the flow of energy density in an electromagnetic wave. And there it works quite satisfactorily because it links electric and magnetic fields of photons. Certainly it is applicable to fields created by a separate charge or set of charges. But its application to the interaction of the fields created by different charges is wrong. Such interaction will be defined in Section 2, and we shall need special axioms for that.

Therefore, complaints that the Poynting vector does not describe, for instance, a static case seem strange. It would be surprising if the Poynting vector described a static case; the

magnetic field of static charge is zero, and only a devoted relativist can create it by running around with tremendous speed!

Therefore Feynman is not right when he comes to conclusion [11, p. 289] that the Poynting vector is directed from outside into a conductor with current, and predicts energy influx into it through a lateral area. The mistake is that he calculates a Poynting vector by substituting into it the external electric field that is directed along the conductor and pushes electrons in it. The electrons' electric field should be substituted into corresponding product. This is the electrons' Coulomb force directed along the radius. And such a flow is directed along conductor, just as Feynman's intuition tells him.

One more strange conclusion is made when it is asserted that (2.1.7*b*) predicts "energy pumping in light wave from electric field to magnetic one and *vice versa*", and that this allegedly sustains the fields vectors' rotation in the light wave. We are compelled to declare that (2.1.7*b*) cannot predict such a pumping because this is an identity in any space–time point; *i.e.,* this description is just different names for the same physical reality. This assertion certainly does not mean that we object that energy is pumped from one field to another one in light wave. We just declare that it cannot be the consequence of the (2.1.7*b*) identity.

Let us also pin point one problem or better to say one problem of interpretation in the theory of retarded potentials. The theory of retarded potentials strives to take into account the every fact that light signal needs some time to pass from source to receiver and sometimes t is really essential. But already at first glance it becomes clear that this is important only for some very rapidly changing processes, or for very distantly situated objects. But the theory declares result to be essential for all cases. Therefore the question appears: isn't there any problem in such declaration?

Let us consider the problem citing an abstract from Feynman textbook [11, eq.21.20 and 21.22]. He considers the velocity of dipole moment $\dot{\mathbf{p}}$ changing not in the current time t, but in the previous moment $(t-r/c)$, where r is the distance from the source and c is light speed. He calculates derivative of $\dot{\mathbf{p}}(t-r/c)$ with respect to spatial coordinate y and obtains

$$\frac{\partial}{\partial y}\dot{\mathbf{p}}\left(t-\frac{r}{c}\right)=-\frac{y}{cr}\ddot{\mathbf{p}}\left(t-\frac{r}{c}\right), \tag{2.1.15}$$

where $\ddot{\mathbf{p}}$ is partial time derivative. This result seems strange. Where partial time derivative could appear from? The correct result must be

$$\frac{\partial}{\partial y}\dot{\mathbf{p}}\left(t-\frac{r}{c}\right)=-\frac{y}{r}\frac{\partial}{\partial r}\dot{\mathbf{p}}\left(t-\frac{r}{c}\right). \tag{2.1.16}$$

See, when we calculate partial derivative the other parameters must be fixed. Let us fix time to spatial coordinate x_0, z_0, then partial derivative with respect to y is the limit

$$\lim_{\Delta y\to 0}\frac{\dot{\mathbf{p}}(t_0-\frac{\sqrt{x_0^2+(y+\Delta y)^2+z_0^2}}{c})-\dot{\mathbf{p}}(t_0-\frac{\sqrt{x_0^2+y^2+z_0^2}}{c})}{\Delta y}. \tag{2.1.17}$$

It is clear that time derivative here can appear from nowhere.

The result (2.1.15) can be understood if Feynman uses the rule for differentiating composite functions. In this case the right hand part in (2.1.15) is just total time derivative or to be more accurate its convective part. Soon we shall see that total time derivative is very essential in electrodynamics. Therefore some Feynman's conclusions later are correct and coincide with the results in our next papers. But the cause lies in actual usage of total time derivative while retardation turns to be just a pretext to use forbidden in to day mainstream physics total time derivative instead of partial one.

To the point: some words about the partial time derivative in (2.1.7*b*). It is written because today orthodox theory demands this. But when we are really drawing the conclusion we are compelled to write total time derivative. Wise Prof. Feynman finds a very good and simple way out: somewhere he writes total and somewhere partial time derivative, leaving the problem to the reader: either this is typesetter misprint or the author's mistake.

The authors of other textbooks are more straightforward. We cite Purcell's textbook here only because it is at hand. One can find similar assertions in many others. On page 233 in his textbook [5], Purcell comes to his formula 29, which coincides with (2.1.7*b*), but total time derivative. Then he writes word for word: "Because $\mathbf{B}$ may depend on position and time us write $\partial\mathbf{B}/\partial t$ instead of $d\mathbf{B}/dt$". And that's all, no explanation in addition. And this is for all that some lines earlier he writes down different combinations of partial derivatives with respect to spatial coordinates. And here he proposes to exclude these coordinates and limit with only time, which was not even mentioned explicitly before. It is typical: the necessity to get the desired answer compels one to constrain logic.

Coming to the end of this historical part, let us say some words about Relativity Theory, because it dominates today's physics and our results will be compared with its predictions. I shall not reproduce all indistinct and paradoxical considerations on which it is based, but only dare declare my deep belief that the "king is nude", and note that many serious scientists in the USA, Russia, and other countries, pinpoint multiple logical contradictions in it. Let us also note that direct experiments to verify the main its assumptions, time dilation and space contraction, showed negative results [12, 13].

But certainly RT could not exist so long if it did not predict correct results at least in some cases. One could note here that Ptolemaic astronomy based on the idea of 7 crystal spheres had existed for almost two millennia, certainly because it correctly predicted many observable facts. Really, Copernicus and Galileo had already said their words, the three Kepler laws had already been well known, but the majority of astronomers were going on calculating in accord with Ptolemaic astronomy. And, by the way, they got better results. I believe no comments are needed here.

Let us finish this Section with some deductions:

1. Different, non-coincident formulas were proposed to describe electrodynamic forces, and all of them were based on the experiments. One can find the review of these formulae in Marinov paper [7, p.186]. Does this not mean that a general formula incorporating all these force laws exists?

2. The force interpretation of the Maxwell system is invalid. Therefore, the field explanation of induction, "flow rule", the very concept of field, turn out to be suspended. Apparently, fields must be understood just as Maxwell equations' solutions. There should be proposed additional axiom (formula) that constructs interaction force from such solutions.

3. Theories of Poynting vector, retarded potentials, are based on logical mistakes, incorrect calculations, or, as in the case of Relativity Theory, on indistinct initial definitions of fundamental notions of space and time. But all of them successfully explain some experimental facts. Any theory claiming to substitute for them must explain all these experiments and propose explanation of many others that are today explained *ad hoc*, or are not explained at all.

2.2. Generalized Maxwell Equations

An approach that the author believes could overcome the drawbacks of present-day electrodynamics that were mentioned in the previous Section is proposed in the present Section.

Let q_1 and q_2 be electric charges 1 and 2, $\mathbf{v}_1$, $\mathbf{v}_2$ and $\mathbf{a}_1$, $\mathbf{a}_2$ be their velocities and accelerations. For simplicity, assume the charges to be distributed evenly in a ball of radius r_0. Let $\mathbf{E}_1$, $\mathbf{E}_2$, $\mathbf{B}_1$, $\mathbf{B}_2$ be electric and magnetic field intensities generated by the charges in space (ether). In the development below, a double index means field intensity created by the charge whose index goes first evaluated at the point where the charge whose index goes second is situated. For instance, $\mathbf{E}_{21}$ means the electric field intensity created by the second charge at the point where the first charge is situated. Let $\mathbf{r}_{21}$ be the radius vector from charge 2 to charge 1, r be its modulus, with $r \gg r_0$.

We have mentioned axiomatic method adopted in modern mathematics above: to formulate initial general suppositions (postulates) and deduct conclusions (theorems) from them.

We shall try to follow this principle expanding it to physics with additional demand that our conclusions (theorem) obtained from such suppositions do not contradict experiment.

Generalized formula for Lorentz force. Charge 2 produces the following force on charge 1

$$\mathbf{F}_{21} = -\nabla\left[4\pi\varepsilon_0 cr^3\left(\mathbf{B}_{12}\cdot\mathbf{E}_{21}\right)\right] + \frac{d}{dt}\left[4\pi\varepsilon_0 cr^3\left(\mathbf{B}_{12}\times\mathbf{B}_{21}\right)\right]. \quad (2.2.1)$$

Here and everywhere below $c = c_0[\mathbf{i}\times\mathbf{j}]\cdot\mathbf{k}$, where c_0 is light speed. This quantity is called "pseudo-scalar light velocity". Supposition about axial character of the light velocity does change anything in habitual electrodynamic theory and add idea about curling component of photo. We shall return to this problem below (also look at §3).

Two notions of force are used in modern physics: the idea inherited from Newton and Descartes as an impulse derivative with respect to time, and the idea inherited from Huygens and Leibnitz as energy gradient. It is believed that these definitions are equivalent. And this is really so if we mean a separate body of constant mass, as it was in the discussed above force definition in the second Newton law. We came to the conclusion there that it was not a law but force definition. We are compelled to assert now that such a definition is, for some reasons, not satisfactory. One of them is the following: the very notion of force means interaction between at least two objects. We cannot describe collision force between two cars while limiting ourselves with the characteristics of only one of them. Therefore, we must acknowledge force definition in the static law of gravity, where two masses participate, or of Coulomb law, where two charges are used, to be natural and understandable. For the same reason, the force definition with the help of Newton's second law must be admitted to be non-satisfactory. Apparently Newton himself felt this, and therefore supplemented it with the third law, which include the second object. This supposition has been already included in (2.2.1) definition. We shall return to this problem in section to this paragraph.

The meaning of formula (2.2.1) is the following: each of the charges moves, creating fields in the surrounding space (ether). Any of these fields depends on some charge's value, its velocity, and its radius vector. The fields may be found as solutions of some equations (for instance Maxwell's system). We construct interaction energy and interaction impulse as a certain combination of these fields. Such combination depends already on two charges' values, their velocities, and the distance between them. The gradient of the interaction energy supplies us with Huygens interaction force, and the total time derivative of the interaction impulse supplies us with the Newton dynamic force, already including Newton's third law in explicit form: the force with which the charge 1 acts on the charge 2 is equal in magnitude and opposite in direction to the force with which the charge 2 acts on the charge 1.

Perhaps it is useful to note that those forces are directed not only along radius-vector but along charges' velocities as well. So constructed forces are not equivalent, but are two items in a generalized understanding of force. Formula (2.2.1) unites these two concepts. The scalar product of the passive charge 1 magnetic field and the active charge 2 electric field describes their interaction energy density, which is written under the gradient symbol. The vector product of the passive charge 1 magnetic field and the active charge 2 magnetic field describes their interaction impulse, which is written under the total time derivative symbol. If we change the charges' roles (the passive becomes active and vice-versa) we obtain the same force with the opposite sign, *i.e.,* (2.2.1) describe action and equal to it antiaction.

To realize this approach, we need certain system of equations. The Maxwell system is used to describe fields in traditional theory. Here, we are compelled to modify Maxwell system in order to coordinate it to formula (2.2.1).

Generalized Maxwell equations. Electric charge q, distributed in the space with density ρ, originates electric and magnetic fields that are solutions of following system:

$$\nabla\cdot\mathbf{E} = \frac{\rho}{\varepsilon_0}, \quad (2.2.2)$$

$$\nabla\times\mathbf{E} = -\frac{d\mathbf{B}}{dt}, \quad (2.2.3)$$

$$\nabla \cdot \mathbf{B} = -\frac{\rho}{c\varepsilon_0}, \tag{2.2.4}$$

$$c^2 \nabla \times \mathbf{B} = \frac{d\mathbf{E}}{dt}. \tag{2.2.5}$$

Let us begin our explanations with the equation (2.2.5)

$$\frac{d\mathbf{E}}{dt} = (\mathbf{v} \cdot \nabla)\mathbf{E} + \frac{\partial \mathbf{E}}{\partial t}. \tag{2.2.6}$$

We assume that velocity depends only on time, and does not depend on spatial coordinates. The first item in the right hand part of (2.2.6) generalizes the idea of a current in classical theory and comes to it if **E** satisfies some additional conditions

$$(\mathbf{v} \cdot \nabla)\mathbf{E} = \mathbf{v}(\nabla \cdot \mathbf{E}) + \nabla \times (\mathbf{E} \times \mathbf{v}) = \frac{\mathbf{j}}{\varepsilon_0} + \nabla \times (\mathbf{E} \times \mathbf{v}), \tag{2.2.6a}$$

where **j** is current density, **j** = ρ**v**. So the right hand part of (2.2.5) contains a curl component in addition to the classical one. This item is manifested for instance in a light wave.

Equation (2.2.4) means that equations (2.2.3)–(2.2.5) generalize the idea of magnetic field. A magnetic field **B** that is the solution of (2.2.3)–(2.2.5) possesses not only a curl but also a divergence component as well. The divergence component of **B** is defined by pseudo-scalar electric charge (defined as usual electric charge divided by a mixed product of unit vectors and light velocity). The **B** appears to be a pseudo-vector, just as in classical theory.

The right hand part of (2.2.4) may be considered as another "incarnation" for electric charge, because the existence of electric charge is both necessary and sufficient for its existence.

One may consider it as a "magnetic charge" as well. But it is necessary to emphasize that such a "magnetic charge" does not coincide with Dirac's monopole. Let us pinpoint some of the differences.

1. Such a magnetic charge is a pseudo-scalar, *i.e.,* its sign changes when a right-handed coordinate triple is changed for a left-handed one.

2. It is c times less than electric charge; correspondingly its dimension differs from the electric charge dimension.

3. And last but not least, (2.2.1) implies that two static "magnetic charges" do not interact, because the second term in (2.2.1) responsible for magnetic interaction is zero in this case. I ask the reader to pay attention to this fact because "ordinary physical mentality" usually identifies field and force, two charges and their inevitable static interaction. We shall see that Newtonian (second) part in (2.2.1) does not contain a static item.

Equality (2.2.2) coincides with the classical equation, but (2.2.3) expands as

$$\frac{d\mathbf{B}}{dt} = (\mathbf{v} \cdot \nabla)\mathbf{B} + \frac{\partial \mathbf{B}}{\partial t}. \tag{2.2.7}$$

So it includes a conventional derivative of **B** originated by electric charge (and correspondingly "magnetic charge") movement with velocity **v**. Classical theory associates the appearance of magnetic field just with the movement of electric charges, but does not include the originating movement into (2.2.3) equation.

The **E** and the **B** in (2.2.2)–(2.2.3) may be defined by means of potentials. Let **A** and φ be the vector and scalar potentials of the electric field, and let them satisfy the following equations

$$\nabla \cdot \nabla \mathbf{A} - \frac{1}{c^2}\frac{d^2\mathbf{A}}{dt^2} = 0, \tag{2.2.8}$$

$$\nabla \cdot \nabla \varphi = -\frac{\rho}{\varepsilon_0}. \tag{2.2.9}$$

Let us assume the following gauge conditions

$$\nabla \cdot \mathbf{A} = -\frac{1}{c^2}\frac{d\varphi}{dt} = 0. \tag{2.2.10}$$

Equations (2.2.10) means that **A** is the curl of a certain vector function. If φ is imagined as a density of a certain "electric liquid", and **A** determines the velocity of such a liquid, then the first part of (2.2.10) is revealed to be a continuity equation for φ and the second part of (2.2.10) becomes a condition of incompressibility for φ.

If we define

$$\mathbf{B} = +\frac{\nabla\varphi}{c} + \nabla \times \mathbf{A}, \tag{2.2.11}$$

$$\mathbf{E} = -\nabla\varphi - \frac{d\mathbf{A}}{dt}, \tag{2.2.12}$$

then (2.2.8)–(2.2.10) comes to (2.2.3)–(2.2.5).

Now we are compelled to concentrate on the point to which modern physics prescribes great importance. This is Maxwell equations invariance with respect to Galilean and Lorentz transformation.

Equations (2.1.6)–(2.1.9) are non-invariant under the Galilean transformation. The letter asserts that

$$\mathbf{r}' = \mathbf{r} - \mathbf{u}t,\ t' = t, \tag{2.2.13}$$

for inertial transformation between unprimed and primed system which moves with constant velocity **u** with respect to the unprimed one

What is the physical meaning of this velocity **u**? The most typical case in hydrodynamics is media movement: previously we observed water particle in a lake (and partial time derivative was enough for us) and we now strive to obtain the same picture in a river where water moves with velocity **u**. Certainly we can observe not only water movement but for instance sand particles which water carries. In the last case **u** will be sand particles velocity in the water with respect to the bank and not water velocity.

How does hydrodynamics take this problem into account? When the process is described in Euler coordinates (as it is in Electrodynamics) total time derivative (2.2.6) is calculated instead of the partial one. We interpreted **v** in (2.2.6) as charge velocity in stationary ether. And what to do if the ether moves as well? Then we assume that the charge will move with velocity **v** + **u**.

About 10 years before Lorentz used his transformation in electrodynamics, Voigt [15] proposed the same transformation in hydrodynamics.

Let us return to water movement in a river. Voigt proposed not to calculate total time derivative, but to come to new

reference frame linked not with the bank but rather with the water in the river. Really, if we produce our experiments on a raft moving with velocity of river water, we can limit ourselves with only partial derivatives. It is clear that everything said above is applicable to the movement of sand particles: their velocity in the lake is **v** with respect to as water as bank, and their velocity in the river is **v** + **u** with respect to bank and **v** with respect to water.

But what will observer on the bank see? He will see the picture so scrupulously described in physical textbooks when Lorentz transformation is commented: he will see that bodies on the raft are contracted in the movement direction and time is dilated. Of course, no a sober hydrodynamicist believes that persons on the raft have lost their flesh and their dying day has been put off. Any sane person understands that this is just a "mathematical mirage". But for believers of relativity theory, such an idea not only does not seem insane, but they declare *in*sane everybody who does not agree with it. God save their mentality!

Therefore let us return to electrodynamics. System (2.1.6)–(2.1.9) is not invariant with respect to Galilean transformation (2.2.13). All the textbooks known to the author declare but do not explain this fact. Therefore, let us say some explanatory words. In Maxwell's time magnetic field was lintred with only electric charges' movement which was introduced by "hands" into the right part of (2.1.9). The "problem of capacitor" compelled Maxwell to introduce also "by hand" the concept of "shift current", *i.e.,* electric field partial time derivative. This means that Maxwell did not understand that electric current concept is included into the notion of convective part, although as we have already mentioned he used just the total time derivative in the corresponding part of his work (p. 595). No kind of current was introduced into Eq. (2.1.7) because nothing that could be interpreted as magnetic charge was observed in experiments of that time. Therefore, the appearance of the magnetic field was linked with electric charges movement only. The existence of magnetic charges was negated. This negation was manifested in correlations (2.1.7) and (2.1.8). Dirac's failure to introduce such charges finally buried the idea. Summing up, one can say that Maxwell formulated his equations for the case of stable ether, and electric current was introduced into it as an axiom based on experiment.

Therefore, when experiments that could be interpreted as ether movement were produced, a problem of generalizing the Maxwell system appeared. Hertz was apparently the first one who thought about it. He solved the problem by introducing the total time derivative into Maxwell's system. Velocity **v** in its convective part was interpreted by him as velocity of ether movement [16]. Thus he had to assume some ether qualities in his model. In particular, he supposed that any ether movement must induce electric phenomena. The ether at that time was believed to be barely connected with electrodynamics, and was even called "light-carrying": the media in which light propagates. Only today we begin understanding that ether determines gravi- and thermodynamic phenomena as well.

But this Hertz idea was not lucky. Soon after his early death, Eichenwald [17] produced an experiment with rotating capacitors that he interpreted as a proof of Lorentz theory of stable ether, and correspondingly refutation of Hertz concept of moving ether, and correspondingly the uselessness of total time derivatives in Maxwell system.

We shall return to Eichenwald's experiments and their interpretation in Section 8. Here we just repeat the assertion formulated above: total time derivatives are useful not only for description of moving ether, but also in the case of stable ether. With their help, we not only naturally introduce conductivity current, but also obtain curl current. We shall see that this current is very essential for explanation of many electrodynamic phenomena.

But this or that way, the fact is that concept of total time derivatives was buried, and the relativistic approach triumphed. Hydrodynamically, this meant that movement of a medium and of particles in this medium were taken into account not with the help of convective derivative but rather with the Voigt method: coming to a moving reference frame.

Everything said above helps us to go to the mathematical side of the problem. System (2.1.6)–(2.1.9) is not Galileo invariant because the partial time derivative in (2.2.13) does not conserve **r** and **r′**, but conserves velocity **u**. Therefore, it is impossible to obtain equality in (2.1.7) and (2.1.9) for moving media, and it is necessary to use the Voigt–Lorentz method, which gives us the desired result by "scratching the left ear with the right hand".

Let us show that system (2.2.2)–(2.2.5) is Galileo invariant (and certainly Lorentz non-invariant). Not to forget, let us mention that system (2.2.2)–(2.2.5) is non-linear, and generally speaking it does not satisfy superposition principle. But we shall not go too far with this question, and postpone it for a separate discussion. Let us come to mathematics. We shall do this following T. Phipps, Jr. [18].

The electric and magnetic fields are:

$$\mathbf{E} = \mathbf{E}(x_1, x_2, x_3, t), \tag{2.2.14}$$

$$\mathbf{B} = \mathbf{B}(x_1, x_2, x_3, t). \tag{2.2.15}$$

If (2.2.13) is valid, how are derivatives in primed and unprimed system connected? We are going to show that

$$\nabla' = \nabla, \ \frac{\partial}{\partial t'} = \frac{\partial}{\partial t} + (\mathbf{u} \cdot \nabla). \tag{2.2.16}$$

Really one obtains using the chain rule:

$$\frac{d}{dx_1} = \frac{dx_1'}{dx_1}\frac{d}{dx_1'} + \frac{dx_2'}{dx_1}\frac{d}{dx_2'} + \frac{dx_3'}{dx_1}\frac{d}{dx_3'} + \frac{dt'}{dx_1}\frac{d}{dt'} = \frac{d}{dx_1'}. \tag{2.2.16a}$$

After repeating the procedure for other coordinates, one obtains

$$\nabla' = \nabla, \tag{2.2.17}$$

if (2.2.13) is valid.

Similarly, since $x_1' = x_1 - u_{x_1} t$, $\frac{\partial x_1'}{\partial t} = -\mathbf{u}_{x_1}$, *etc*, we have

$$\frac{\partial}{\partial t} = \frac{\partial}{\partial t'} - (\mathbf{u} \cdot \nabla') = \frac{\partial}{\partial t'} - (\mathbf{u} \cdot \nabla). \tag{2.2.18}$$

One can see that traditional Maxwell system (2.1.6)–(2.1.9) is not invariant under Galilean transformation. For instance, when we have come to another inertial system moving with constant velocity **u**, the additional term (**u**·∇) appears in the right hand

part of (2.1.7), and this term is not compensated in the left hand part of (2.1.7). In today's physics, the problem was solved by usage of Lorentz transformation. Identity (2.2.6) shows that this problem also disappears if total time derivative is used: additional terms are annihilated.

Vector **v** in (2.2.6) is interpreted as charge velocity. It appears even in immovable media, *i.e.,* in the fixed frame reference. And it remains invariant if we come to another inertial frame moving with constant velocity **u**. In this case (2.2.6) will look as follows

$$\frac{d\mathbf{E}}{dt}=\big((\mathbf{u}+\mathbf{v})\cdot\nabla\big)\mathbf{E}-(\mathbf{u}\cdot\nabla)\mathbf{E}+\frac{\partial\mathbf{E}}{\partial t}=(\mathbf{v}\cdot\nabla)\mathbf{E}+\frac{\partial\mathbf{E}}{\partial t}. \tag{2.2.19}$$

But we cannot agree with the Dr. Phipps' idea that field equations must include sink or detector velocity. Another charge plays role of sink, or detector. How this sinking and detection takes place must be defined by special additional postulate and cannot be obtained from the equations describing fields originated by one charge. Therefore we cannot obtain charges' interaction formulas (either Lorentz or any other) from Maxwell equations. Formula (2.2.1) is just such an axiom that describes the interaction between "source" and "sink". The following Sections will be devoted to revealing it.

Based on purely mathematical reasoning, the right hand part of (2.2.4) must be a pseudoscalar. But what is physical essence of this demand?

It will be shown in §3 that the dielectric constant ε_0 means free ether mass density, and the magnetic constant μ_0 means free ether compressibility. Therefore, it is more natural to speak not only about light speed, but also about the whole coefficient $1/\varepsilon_0 c$; *i.e.,* about free ether impedance.

The equality $c^2 = 1/\varepsilon_0\mu_0$ means that we can write $\sqrt{\mu_0/\varepsilon_0}$ instead of $1/\varepsilon_0 c$. Thus the magnetic field divergence is proportional to free ether impedance, in contrast to electric field divergence, which is ε_0 inverse, and does not depend on μ_0. The pseudo scalar character of the $\sqrt{\mu_0/\varepsilon_0}$ coefficient means that if we use right hand coordinate triple, we must take the radical sign minus in the right hand part of (2.2.4), and in the opposite case, we must take plus. The only explanation of this fact that I can imagine is that ether polarization is manifested when a magnetic field extends. And this polarization makes left hand and right hand rotations non-equivalent. This non-equivalence does not influence electric field divergence. The situation is *vice versa* for rotational parts of the fields: ether polarization influences the electric field and does not influence magnetic field.

2.3. The Field Formula

Equations (2.2.2)–(2.2.5) define in differential form the fields **E** and **B** originated by moving charges. They are just the fields one needs in order to use formula (2.2.1).

Mathematically, the system (2.2.2)–(2.2.5) dissociates into two groups. Equations (2.2.3) and (2.2.5) define the **E** and the **B** fields that are their solutions. And this is enough: in order to find two vector-functions **E** and **B** we need only two vector equations, not more, and not less. But system (2.2.2)–(2.2.5) contains two scalar (divergence) equations in addition. Does this mean that system (2.2.2)–(2.2.5) is over-determined? Accurate analysis shows that correlations (2.2.2) and (2.2.4) are actually initial conditions for **E** and **B**; *i.e.,* (2.2.2) and (2.2.4) may by written:

$$\mathbf{E}(0,\mathbf{r})=\frac{\rho}{3\varepsilon_0}\mathbf{r}; \tag{2.3.1}$$

$$\mathbf{B}(0,\mathbf{r})=-\frac{\rho}{3\varepsilon_0 c}\mathbf{r}; \tag{2.3.2}$$

$$\nabla\cdot\mathbf{E}(0,\mathbf{r})=\frac{\rho}{\varepsilon_0}+\frac{\rho}{3\varepsilon_0}(\nabla\rho)\cdot\mathbf{r}; \tag{2.3.3}$$

$$\nabla\cdot\mathbf{B}(0,\mathbf{r})=-\frac{\rho}{\varepsilon_0 c}-\frac{1}{3\varepsilon_0 c}(\nabla\rho)\cdot\mathbf{r}. \tag{2.3.4}$$

We assumed above that charge q was evenly distributed in a ball of radius r_0; *i.e.,*

$$\nabla\rho=0. \tag{2.3.4a}$$

We have thus come to (2.2.2) and (2.2.4). One can verify that (2.2.2) and (2.2.5) imply that

$$\frac{d\rho}{dt}=\frac{\partial\rho}{\partial t}+\mathbf{v}\cdot(\nabla\rho)=0. \tag{2.3.5}$$

In other words, our assumption concerning ρ yields in addition that the partial time derivative

$$\frac{\partial\rho}{\partial t}=0. \tag{2.3.6}$$

We also assume that **v** is independent of spatial coordinates; *i.e.,*

$$\mathbf{v}=\mathbf{v}(t). \tag{2.3.7}$$

Under conditions (2.3.4*a*)–(2.3.7) one can find a partial solution of (2.2.2)–(2.2.5). This is

$$\mathbf{E}=\frac{\rho}{3\varepsilon_0}\left[-\frac{(\mathbf{r}\times\mathbf{v})}{c}+\mathbf{r}\right], \tag{2.3.8}$$

$$\mathbf{B}=-\frac{\rho}{3\varepsilon_0 c}\left[\frac{(\mathbf{r}\times\mathbf{v})}{c}+\mathbf{r}\right], \tag{2.3.9}$$

where **r** is the radius-vector from the charge to the observation point. Let us verify (2.3.8) and (2.3.9) by direct substitution, and show that they are really solutions of the modified Maxwell's equations (2.2.2)–(2.2.5).

$$\nabla\cdot\mathbf{E}=\frac{\nabla\rho}{3\varepsilon_0}\left[-\frac{(\mathbf{r}\times\mathbf{v})}{c}+\mathbf{r}\right]+\frac{\rho}{c\varepsilon_0}\nabla\cdot\left[-\frac{(\mathbf{r}\times\mathbf{v})}{c}+\mathbf{r}\right]=\frac{\rho}{\varepsilon_0}. \tag{2.3.10}$$

In just the same way

$$\nabla\cdot\mathbf{B}=-\frac{\rho}{\varepsilon_0 c}. \tag{2.3.11}$$

Let us calculate left and right hand parts of (2.2.3)

$$\varepsilon_0 \frac{d\mathbf{B}}{dt} = -\frac{1}{3}\frac{d\rho}{dt}\left[\frac{\mathbf{r}\times\mathbf{v}}{c^2}+\frac{\mathbf{r}}{c}\right]-\frac{\rho}{3c}\left[\frac{\mathbf{v}\times\mathbf{v}}{c}+\frac{\mathbf{r}\times\mathbf{a}}{c}+\mathbf{v}\right]= \\ = -\frac{\rho}{3c}\left[\frac{\mathbf{r}\times\mathbf{a}}{c}+\mathbf{v}\right]. \tag{2.3.12}$$

In the text below we assume that the first item in the last expression here is zero; *i.e.,* we assume that either the radius vector is perpendicular to the acceleration $\mathbf{a}$, or else $\mathbf{a}$ is zero; *i.e.,* the velocity is constant. One obtains finally

$$\frac{d\mathbf{B}}{dt} = -\frac{\rho\mathbf{v}}{3c\varepsilon_0}. \tag{2.3.13}$$

On the other hand

$$\varepsilon_0 \nabla\times\mathbf{E} = \frac{1}{2}\left\{\nabla\frac{\rho}{3}\times\left[-\frac{\mathbf{r}\times\mathbf{v}}{c}+\mathbf{r}\right]+ \right. \\ \left. +\frac{\rho}{3c}\left[-(\mathbf{v}\cdot\nabla)\mathbf{r}+(\mathbf{r}\cdot\nabla)\mathbf{v}-(\nabla\cdot\mathbf{v})\mathbf{r}+(\nabla\cdot\mathbf{r})\mathbf{v}\right]\right\} = +\frac{\rho\mathbf{v}}{3c}. \tag{2.3.14}$$

Here we have assumed the definition of "∇×" as one half of the corresponding combination of partial derivatives because such definition is adopted in the Russian Mathematical Encyclopedia [19]. Equation (2.2.5) is verified in the same way. If "∇×" is defined without this factor of one half, a 2 appears in vector product items in (2.3.8) and (2.3.9). Equation (2.2.5) is verified in the same way.

2.4. The Final Correlation

Let us write down in explicit form the items appearing in the formula (2.2.1):

1. $\mathbf{B}_{12} = -\frac{q_1}{4\pi\varepsilon_0 r^3 c}\left[\frac{\mathbf{r}_{12}\times\mathbf{v}_1}{c}+\mathbf{r}_{12}\right] = \frac{q_1}{4\pi\varepsilon_0 r^3 c}\left[\frac{\mathbf{r}_{21}\times\mathbf{v}_1}{c}+\mathbf{r}_{21}\right];$

2. $\mathbf{E}_{21} = \frac{q_2}{4\pi\varepsilon_0 r^3}\left[-\frac{\mathbf{r}_{21}\times\mathbf{v}_2}{c}+\mathbf{r}_{21}\right].$

Let us find the gradient of the scalar product of these fields:

3. $\mathbf{B}_{12}\cdot\mathbf{E}_{21} = -\frac{q_1 q_2}{16\pi^2\varepsilon_0^2 r^6 c}\left[\frac{(\mathbf{r}_{21}\times\mathbf{v}_1)\cdot(\mathbf{r}_{21}\times\mathbf{v}_2)}{c^2}-r^2\right]r;$

4. $-\nabla\left[4\pi\varepsilon_0 r^3 c(\mathbf{B}_{12}\cdot\mathbf{E}_{21})\right] = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\left[\mathbf{r}_{21}-\frac{3\mathbf{r}_{21}\left((\mathbf{r}_{21}\times\mathbf{v}_1)\cdot(\mathbf{r}_{21}\times\mathbf{v}_2)\right)}{r^2c^2}+\frac{\mathbf{v}_1\times(\mathbf{r}_{21}\times\mathbf{v}_2)+\mathbf{v}_2\times(\mathbf{r}_{21}\times\mathbf{v}_1)}{c^2}\right].$

Now the second item in (2.2.1) is found

5. $\mathbf{B}_{12} = -\frac{q_2}{4\pi\varepsilon_0 r^3 c}\left[\frac{\mathbf{r}_{21}\times\mathbf{v}_2}{c}+\mathbf{r}_{21}\right];$

6. $\mathbf{B}_{12} = \frac{q_1}{4\pi\varepsilon_0 r^3 c}\left[\frac{\mathbf{r}_{21}\times\mathbf{v}_1}{c}+\mathbf{r}_{21}\right];$

7. $4\pi\varepsilon_0 r^3 c(\mathbf{B}_{12}\times\mathbf{B}_{21}) = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3 c}\left[\frac{(\mathbf{r}_{21}\times\mathbf{v}_2)\times(\mathbf{r}_{21}\times\mathbf{v}_1)}{c^2}+\mathbf{r}_{21}\times\frac{\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2)}{c}\right].$

The first and second time derivatives of the radius vector are

$$\frac{d\mathbf{r}_{21}}{dt} = \mathbf{v}_1-\mathbf{v}_2, \quad \frac{d^2\mathbf{r}_{21}}{dt^2} = \mathbf{a}_1-\mathbf{a}_2.$$

If the problem conditions are essentially independent of the signal retardation, the derivatives are calculated at the time t. If retardation is essential, the derivatives are calculated at the previous time $\tau = t - r/c_0$.

The second term in (2.2.1) appears as follows

8. $\frac{d}{dt}\left[4\pi\varepsilon_0 r^3 c(\mathbf{B}_{12}\times\mathbf{B}_{21})\right] =$

$$= \frac{q_1q_2}{4\pi\varepsilon_0 r^3 c^2}\cdot\left\{\left[(\mathbf{v}_1-\mathbf{v}_2)\times(\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2))\right]-\frac{3\mathbf{r}_{21}\cdot(\mathbf{v}_1-\mathbf{v}_2)}{r^2}\left[\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2))\right]+\mathbf{r}_{21}\times\left[\mathbf{r}_{21}\times(\mathbf{a}_1-\mathbf{a}_2)\right]+\right. \\ \left. +\frac{(\mathbf{v}_1\times\mathbf{v}_2)\times\left[(\mathbf{r}_{21}\times\mathbf{v}_1)-(\mathbf{r}_{21}\times\mathbf{v}_2)\right]}{c}+\frac{\left[(\mathbf{r}_{21}\times\mathbf{v}_2)\times(\mathbf{r}_{21}\times\mathbf{a}_1)-(\mathbf{r}_{21}\times\mathbf{v}_1)\times(\mathbf{r}_{21}\times\mathbf{a}_2)\right]}{c}-\frac{3\mathbf{r}_{21}\cdot(\mathbf{v}_1-\mathbf{v}_2)\cdot\left[(\mathbf{r}_{21}\times\mathbf{v}_2)\times(\mathbf{r}_{21}\times\mathbf{v}_1)\right]}{r^2c}\right\}.$$

Finally one obtains the force the second charge exerts on the first one:

$$\mathbf{F}_{21} = \frac{q_1q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}+\frac{q_1q_2}{4\pi\varepsilon_0 r^3c^2}\cdot\left\{\mathbf{v}_1\times(\mathbf{r}_{21}\times\mathbf{v}_2)+\mathbf{v}_2\times(\mathbf{r}_{21}\times\mathbf{v}_1)-\frac{3\mathbf{r}_{21}}{r^2}\left((\mathbf{r}_{21}\times\mathbf{v}_1)(\mathbf{r}_{21}\times\mathbf{v}_2)\right)+\left[(\mathbf{v}_1-\mathbf{v}_2)\times(\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2))\right]-\right. \\ -\frac{3\mathbf{r}_{21}\cdot(\mathbf{v}_1-\mathbf{v}_2)}{r^2}\left[\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2))\right]+\left[\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\mathbf{a}_1-\mathbf{a}_2))\right]+\frac{(\mathbf{v}_1\times\mathbf{v}_2)\times\left[(\mathbf{r}_{21}\times\mathbf{v}_1)-(\mathbf{r}_{21}\times\mathbf{v}_2)\right]}{c}+ \\ \left. +\frac{\left[(\mathbf{r}_{21}\times\mathbf{v}_2)\times(\mathbf{r}_{21}\times\mathbf{a}_1)-(\mathbf{r}_{21}\times\mathbf{v}_1)\times(\mathbf{r}_{21}\times\mathbf{a}_2)\right]}{c}-\frac{3\mathbf{r}_{21}\cdot(\mathbf{v}_1-\mathbf{v}_2)\left[(\mathbf{r}_{21}\times\mathbf{v}_1)\times(\mathbf{r}_{21}\times\mathbf{v}_2)\right]}{r^2c}\right\}. \tag{2.4.1}$$

By revealing triple vector products one obtains another expression for the same force

$$\mathbf{F}_{21}=\frac{q_1q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}+\frac{q_1q_2}{4\pi\varepsilon_0 r^3c^2}\cdot\left\{\left[2\mathbf{r}_{21}(\mathbf{v}_1\cdot\mathbf{v}_2)-\mathbf{v}_1(\mathbf{r}_{21}\cdot\mathbf{v}_2)-\mathbf{v}_2(\mathbf{r}_{21}\cdot\mathbf{v}_1)-\frac{3\mathbf{r}_{21}}{r^2}((\mathbf{r}_{21}\cdot\mathbf{v}_1)(\mathbf{r}_{21}\cdot\mathbf{v}_2))\right]+\right.$$
$$+\left[\mathbf{r}_{21}(\mathbf{v}_1-\mathbf{v}_2)^2-(\mathbf{v}_1-\mathbf{v}_2)(\mathbf{r}_{21}(\mathbf{v}_1-\mathbf{v}_2))\right]--\frac{3\mathbf{r}_{21}(\mathbf{v}_1-\mathbf{v}_2)}{r^2}\left[\mathbf{r}_{21}(\mathbf{r}_{21}(\mathbf{v}_1-\mathbf{v}_2))-(\mathbf{v}_1-\mathbf{v}_2)r^2\right]+$$
$$+\left[\mathbf{r}_{21}(\mathbf{r}_{21}(\mathbf{a}_1-\mathbf{a}_2))-(\mathbf{a}_1-\mathbf{a}_2)r^2\right]+\frac{(\mathbf{v}_2-\mathbf{v}_1)(\mathbf{r}_{21}(\mathbf{v}_1\times\mathbf{v}_2))}{c}+\frac{\mathbf{r}_{21}\left[(\mathbf{r}_{21}\times\mathbf{v}_2)\mathbf{a}_1-(\mathbf{r}_{21}\times\mathbf{v}_1)\mathbf{a}_2\right]}{c}+ \tag{2.4.2}$$
$$\left.+\frac{3\mathbf{r}_{21}\left[\mathbf{r}_{21}(\mathbf{v}_1-\mathbf{v}_2)\right]\left[\mathbf{r}_{21}(\mathbf{v}_1\times\mathbf{v}_2)\right]}{r^2c}\right\}.$$

Let us find another form of the force (2.4.2) explicitly introducing the angles between the vectors.
Let:
θ_1 – be the angle between $\mathbf{r}_{21}$ and $\mathbf{v}_1$;
θ_2 – be the angle between $\mathbf{r}_{21}$ and $\mathbf{v}_2$;
θ_3 – be the angle between $\mathbf{v}_1$ and $\mathbf{v}_2$;
θ_4 – be the angle between $\mathbf{r}_{21}$ and $(\mathbf{v}_1-\mathbf{v}_2)$;
θ_5 – be the angle between $\mathbf{r}_{21}$ and $(\mathbf{a}_1-\mathbf{a}_2)$;
θ_6 – be the angle between $\mathbf{r}_{21}$ and $(\mathbf{v}_1\times\mathbf{v}_2)$;
θ_7 – be the angle between $(\mathbf{r}_{21}\times\mathbf{v}_2)$ and $\mathbf{a}_1$;
θ_8 – be the angle between $(\mathbf{r}_{21}\times\mathbf{v}_1)$ and $\mathbf{a}_2$.
Then (2.4.2) appears as follows

$$\mathbf{F}_{21}=\frac{q_1q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}+\frac{q_1q_2}{4\pi\varepsilon_0 r^3c^2}\cdot\left\{\left[-\mathbf{v}_1 v_2 r\cos\theta_1-\mathbf{v}_2 v_1 r\cos\theta_2+\mathbf{r}_{21}v_1v_2\left(2\cos\theta_3-3\cos\theta_1\cos\theta_2\right)\right]+\right.$$
$$+\left[\mathbf{r}_{21}(\mathbf{v}_1-\mathbf{v}_2)^2\left(1-3\cos^2\theta_4\right)+2(\mathbf{v}_1-\mathbf{v}_2)\,r|\mathbf{v}_1-\mathbf{v}_2|\cos\theta_4\right]+\left[\mathbf{r}_{21}r|\mathbf{a}_1-\mathbf{a}_2|\cos\theta_5-(\mathbf{a}_1-\mathbf{a}_2)r^2\right]+ \tag{2.4.3}$$
$$\left.+\frac{(\mathbf{v}_2-\mathbf{v}_1)rv_1v_2\cos\theta_6\sin\theta_3}{c}+\frac{\mathbf{r}_{21}\cdot\left[ra_1v_2\sin\theta_2\cos\theta_7-ra_2v_1\sin\theta_1\cos\theta_8\right]}{c}+\frac{3\mathbf{r}_{21}\cdot[(v_1-v_2)(v_1\cdot v_2)]\cos\theta_4\cos\theta_6}{c}\right\}.$$

One can see that Neumann, Grassmann, Ampere and Whittaker formulas mentioned in paragraph 1 are special cases of the gradient part of formula (2.4.2). They are all terms in the first square brackets. Really (2.1.14*a*) is just the first item there, (2.1.14*b*) is the first and the third items, (2.1.14*c*) is the doubled first and the forth ones, (2.1.14*d*) is the first, the second and the third items. It is worthwhile to note that Grassmann's formula (2.1.14*b*) accurately coincides with Lorentz's formula (2.1.14) when integrated over current contour. It is understandable that all the above mentioned authors proposed terms from the first square bracket in (2.4.2). They all experimented with current loops, *i.e.*, with neutral currents, for which as we shall see the second, third and fourth square brackets in (2.4.2) are zero.

But Weber [20] somehow managed to come to the items in the second, the third and the forth brackets in (2.4.2). Perhaps he experimented just with charged currents, but he came to the radial items in the brackets. The first square bracket coincides with New Gaussian formula (2.1.5) if time is calculated in accord with *universal time postulate*. In contrast to Weber's formula, it contains not only radial terms, but also terms directed along the velocity difference.

Let us try to clarify the physical essence of the formula obtained. All the derivatives here are calculated with respect to the laboratory frame of reference.

Let us return to functions (2.3.8) and (2.3.9). The second terms in their right hand sides define static components that are manifested only for "bare charges":

The first terms define dynamic components, and they are manifested not only for charged currents but for neutral ones as well. This quality is inherited when these components are multiplied and when derivatives are calculated in formula (2.2.1). For instance the first item in (2.4.1)–(2.4.3) in obtained as a gradient of the static components' product. Therefore it is valid only for "bare charges" (Coulomb law). On the contrary, the first square bracket is a result of the product of dynamic components. So it is valid for neutral currents' as well. One can easily see that this square bracket is a symmetrization of the classical Lorentz force in a way such that it begins satisfying the third Newtonian law plus Ampere force.

The second square bracket in (2.4.1)–(2.4.3) is a product of dynamic and static components. So it is equal to zero between two neutral currents. It is valid if at least one of the currents is charged. This square bracket depends on the difference between charges velocities, and predicts all experimentally verified effects of Relativity Theory without "time dilation" and "space contraction". It also predicts a force produced on a "bare charge" at rest near a neutral current.

The third square bracket depends on the charges accelerations and describes field radiation. It is valid for all kinds of currents because the radiated field should be considered as a

"nude" one. It often predicts the same result as classical theory, but Example 2 in Section 5 shows that it predicts no radiation for an electron rotating around positive charge.

The last three terms in braces are proportional to inverse c^3. They are apparently essential in electro-weak interactions.

2.5. Example Applications

Example 1. Comparison with relativity Theory.

Let test charge q_1 be evenly distributed along the circumference of a circle of radius R_0 situated in the (x_1, x_2) plane at the center in the coordinate system origin. The charge q_2 is at rest in the center of the circle. The classical Lorentz formula and the formula (2.4.3) predict only a Coulomb force directed along the radius. Let q_2 move with constant velocity $\mathbf{v}$ along the x_1 axis. Today theory predicts that relativistic effects exist in this case. They are believed to change the Coulomb force magnitude but to preserve its radial character. This force is considered to be

$$F_e = \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} \cdot \frac{(1-\beta^2)}{(1-\beta^2 \sin^2\theta)^{3/2}}, \tag{2.5.1}$$

where $\beta = v/c$, and θ is the angle between $\mathbf{v}$ the and radius-vector to q_1.

When β is small enough that it is possible to expand (2.5.1) in a series, one gets

$$F_e = \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} + \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} \cdot \frac{\beta^2}{2}(1 - 3\cos^2\theta). \tag{2.5.1a}$$

When $\theta = 0$, (2.5.1*a*) predicts Coulomb force multiplication by a factor of β^2; *i.e.*, force decrease. When $(1 - \cos^2\theta) = 0$ (at about 55° and 125°), the second term in (2.5.1*a*) is zero. The Coulomb force acts on the points where the additional force changes its sign. When $\theta = 90°$ (2.5.1*a*) predicts force factor $\beta^2/2$; *i.e.*, overall force increase. When β increases, other terms in the series expansion become essential, so (2.5.1*a*) becomes incorrect and we must use (2.5.1).

Let us see predictions of the (2.4.3) formula. Only the second square bracket in (2.4.3) is nonzero for the small β case. The bracket predicts two forces: a force F_r that is radial, and a force F_v that is directed along the velocity.

One obtains for the radial force magnitude:

$$F_r = \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} + \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} \cdot \beta^2(1 - 3\cos^2\theta). \tag{2.5.2}$$

One can see that, in comparison with (2.5.1*a*), (2.5.2) predicts for small β a result that is qualitatively similar, but twice greater. The difference with (2.5.1) in the transverse direction ($\theta = 90°$) decreases with increasing β. When $\beta^2 \approx 3/4$, (2.5.1) is already bigger than (2.5.2). And when $\beta \to 1$, $F_e \to \infty$ and F_r approaches double the Coulomb force in the direction perpendicular to $\mathbf{v}$ ($\theta = 90°$). Let us note that (2.5.2) is also valid when one of the currents is neutral (for instance, q_1 is distributed in a neutral conductor).

The velocity force has magnitude

$$F_v = \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} \cdot \beta^2 \cos\theta. \tag{2.5.3}$$

The force is maximum when $\theta = 0$ (longitudinal direction). When θ is in the interval [0, 90°], the force decreases from $\frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2}\beta^2$ to zero, and when θ is in the interval [90°, 180°], F_v goes on decreasing from zero to $-\frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2}\beta^2$. The overall force produced on a charged circumference is the sum

$$\mathbf{F}_k = \mathbf{F}_v + \mathbf{F}_r. \tag{2.5.4}$$

$\mathbf{F}_v$ originates tangential to the circumferential force. If q_2 is a negative charge and the circumference is a neutral conductor, then free electrons gather in the region where the circumference crosses x_1 axis. Correspondingly, the x_3 axis and the circumference intersection are charged positively. This charging goes on until the mechanical moment due to the Coulomb force balances the moment transferred to the system by the external forces that give velocity "$\mathbf{v}$" to the charge (see details in Sect. 10). If the velocity of charge q_2 is not constant, *i.e.*, q_2 has some acceleration $\mathbf{a}$, an additional force [the third square bracket in (2.4.3)] is produced on the circumferential charges. Its magnitude is

$$F_a = \frac{q_1 q_2 a}{4\pi\varepsilon_0 c^2 R_0^2} \cdot \sin\theta.$$

If the directions of velocity and acceleration coincide, then this force is maximal at the intersection of the circumference and the x_3 axis ($\theta = 90°$). On the intervals [0°, 90°], [90°, 180°], it decreases without changing its sign. One can compare it with the F_v, which decreases on the interval [0°, 180°], and has different signs on the intervals mentioned.

Some deductions follow:

1. Formula (2.4.3) predicts two (or in the case of accelerated movement – three) forces produced on a test charge.

2. The acceleration force coincides with the classical one. The radial force is close to relativity theory predictions in a wide range of velocities. But the velocity force is not predicted by today electrodynamics, and may be used for experimental verification of the proposed scheme.

Example 2. A Rotating charge does not radiate.

Let a positive charge q_2 be al rest, *i.e.*, $\mathbf{v}_2 = 0$, $\mathbf{a}_2 = 0$. A negative charge q_1 rotates around q_2 with constant speed $\mathbf{v}_1$ and correspondingly with constant centripetal acceleration magnitude $\mathbf{a}_1$. What effects does (2.4.3) predict?

The first square bracket in (2.4.3) is zero because $\mathbf{v}_2 = 0$. The third square bracket is zero because $\mathbf{a}_1$ is parallel to $\mathbf{r}_{21}$. (One can see this especially clearly in (2.4.1)), $\theta_4 = 90°$, *i.e.*, $\cos\theta_4 = 0$. One gets finally

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21} + \frac{q_1 q_2 \mathbf{v}_1^2}{4\pi\varepsilon_0 r^3 c^2}\mathbf{r}_{21}. \tag{2.5.5}$$

Eq. (2.5.5) predicts no force produced on q_1 because of centripetal acceleration, hence q_1 does not radiate. Such radiation takes place only if q_1 is accelerated tangentially.

Eq. (2.5.5) predicts radial force that augments the Coulomb force. In the case of an elliptic orbit, this force leads to orbit rotation as a unit (pericenter shift). It is just an accurate analogue to the case of pericenter shift of the planetary orbits in gravity.

Example 3. A non-traditional force arises.

Let two charges of the same sign, q_1 and q_2, move along parallel straight lines with equal constant velocities; *i.e.*, $\mathbf{v}_1 = \mathbf{v}_2 = \mathbf{v}$, $\theta_1 = \theta_2 = \theta$, $\cos\theta_3 = 1$, and only the first bracket is nonzero

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21} - \frac{q_1 q_2 v^2 (2-3\cos^2\theta)}{4\pi\varepsilon_0 r^3 c^2}\mathbf{r}_{21} - \frac{2 q_1 q_2 v\cos\theta}{4\pi\varepsilon_0 r^2 c^2}\mathbf{v}. \quad (2.5.6)$$

Force (2.5.6) implies that in addition to the Coulomb force (the second term) the radial force $\mathbf{F}_r$ directed along radius $\mathbf{r}$ and the force $\mathbf{F}_v$ directed along velocity (the third term) are produced on charge 1.

When $2 - 3\cos^2\theta = 0$ (approximately 35.3° and 144.7°), the radial force $\mathbf{F}_r$ is zero. When θ is in the interval [0°, 35.3°) and θ is in the interval (144.7°, 180°] $\mathbf{F}_r$ is positive and augments the Coulomb force. When θ is in the interval (35.3°, 144.7°), $\mathbf{F}_r$ is negative, and "weakens" the Coulomb force. The velocity force is equal to zero when θ = 90°, *i.e.*, charges fly "side by side". When θ is in the interval (90°, 180°) (the first charge is behind the second one), $\mathbf{F}_v$ is directed along the first charge velocity and accelerates it (the second charge "helps" its partner to fly). When θ is in the interval (0°, 90°) (the first charge is before the second one), $\mathbf{F}_v$ is directed against the velocity of the first charge (the second charge breaks the first one movement). A force equal in magnitude and opposite in direction is produced on the second charge. So the equilibrium point for the charge is going "side by side".

If there are two beams instead of two separate charges, the velocity force $\mathbf{F}_v$ separates the beams into clusters that strive to move "side by side". We observe a "cluster effect". The force $\mathbf{F}_r$ weakens the Coulomb force between charges.

2.6. Charge 2 Distributed Along Infinite Straight Line

Let q_2 be distributed with constant density λ along the x_3 axis. This means that boundary conditions (2.2.2) and (2.2.4) must be changed. We assume that initial condition (2.2.2) is

$$\nabla\cdot\mathbf{E}_2 = +\frac{\lambda}{2\pi\varepsilon_0 r^2},\ r > r_0. \quad (2.6.1)$$

where

$$\mathbf{E}_2 = -\frac{\lambda}{2\pi\varepsilon_0 r}.$$

and r_0 is the wire radius. Instead of item 2 of Sect. 4, one obtains

$$\mathbf{E}_{21} = \frac{\lambda}{2\pi\varepsilon_0 r^2}\left[\frac{\mathbf{r}_{21}\times\mathbf{v}_2}{c} - \mathbf{r}_{21}\right].$$

In the same way

$$\mathbf{B}_{21} = -\frac{\lambda}{2\pi\varepsilon_0 r^2 c}\left[\frac{\mathbf{r}_{21}\times\mathbf{v}_2}{c} + \mathbf{r}_{21}\right].$$

If the calculations of Section 4 are repeated for the charge q_1, one finds

$$\begin{aligned}\mathbf{F}_{21} = {} & \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} - \frac{q_1\lambda}{2\pi\varepsilon_0 r^2 c^2}\cdot\left\{\left[\left((\mathbf{v}_1\cdot\mathbf{v}_2) + \frac{2(\mathbf{r}_{21}\cdot\mathbf{v}_1)(\mathbf{r}_{21}\cdot\mathbf{v}_2) - (\mathbf{r}_{21}\cdot\mathbf{v}_1)(\mathbf{r}_{21}\cdot\mathbf{v}_2)}{r^2}\right)\mathbf{r}_{21} - \mathbf{v}_1(\mathbf{r}_{21}\cdot\mathbf{v}_2) - \mathbf{v}_2(\mathbf{r}_{21}\cdot\mathbf{v}_1)\right]\right. \\ & \left. + \left[(\mathbf{v}_1-\mathbf{v}_2)\times(\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2))\right] - \frac{2\mathbf{r}_{21}\cdot(\mathbf{v}_1-\mathbf{v}_2)}{r^2}\left[\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2))\right] + \left[\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\mathbf{a}_1-\mathbf{a}_2))\right]\right\}.\end{aligned} \quad (2.6.2)$$

Let us assume that the charged straight wire (axis x_3) does not move as a unit, *i.e.*, $\mathbf{v}_2 = 0$, $\mathbf{a}_2 = 0$, so $(\mathbf{r}_{21}\cdot\mathbf{v}_2) = 0$, $(\mathbf{r}_{21}\cdot\mathbf{a}_2) = 0$. And let us reveal the triple vector product in (2.6.2) while taking this condition into account

$$\begin{aligned}\mathbf{F}_{21} = {} & \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} - \frac{q_1\lambda}{2\pi\varepsilon_0 r^2 c^2}\left\{\left[v_1 v_2\cos\theta_3\mathbf{r}_{21} - r v_1\cos\theta_1\mathbf{v}_2\right] + \left[(\mathbf{v}_1-\mathbf{v}_2)^2\cdot(1-2\cos^2\theta_4)\right]\mathbf{r}_{21} - \right. \\ & \left. -\left[2r|\mathbf{v}_1-\mathbf{v}_2|\cos\theta_4\right](\mathbf{v}_1-\mathbf{v}_2) + \left[r a_1\cos\theta_5\mathbf{r}_{21} - (\mathbf{a}_1-\mathbf{a}_2)r^2\right]\right\}.\end{aligned} \quad (2.6.3)$$

Let us note that the first square bracket in (2.6.3) coincides with dynamic part of traditional Lorentz force, if the magnetic field of the charged straight line (charged wire) is revealed with respect to velocities of charges creating it.

2.7. More Examples of GE vs. Traditional Results

Example 1. The Lorentz force is a special case of GE.

The Lorentz force law is a special case of Generalized Electrodynamics (GE). Let charge q_1 move parallel to x_3 with the same velocity as charge q_2 along x_3, *i.e.*, $\mathbf{v}_1 = \mathbf{v}_2 = \mathbf{v}$.

All the square brackets in (2.6.3) are equal to zero except for the first one, in which $\cos\theta_1 = 0$, $\cos\theta_3 = 1$. One obtains finally

$$\mathbf{F}_{21} = \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} - \frac{q_1\lambda v^2}{2\pi\varepsilon_0 r^2 c^2}\mathbf{r}_{21}. \tag{2.7.1}$$

This formula coincides with the prediction of the Lorentz force formula.

Example 2. GE predicts the traditional effect again.

In the previous Example 1, let $\mathbf{v}_1 = -\mathbf{v}_2 = \mathbf{v}$, *i.e.*, let q_1 move anti-parallel to the charges in the wire. The first and the second square brackets in (2.6.3) are nonzero for the case that $\cos\theta_1 = 0$, $\cos\theta_3 = -1$

$$\mathbf{F}_{21} = \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} + \frac{q_1\lambda v^2}{2\pi\varepsilon_0 r c^2}\mathbf{r}_{21}. \tag{2.7.2}$$

again we have got coincidence with classical case.

Example 3. A new force appears.

Let the first charge move perpendicular to the x_3 axis, going away from the wire along a radius vector. The first two square brackets in (2.6.3) are nonzero, $\cos\theta_1 = 1$, $\cos\theta_3 = 0$, $\cos\theta_4 = \cos\theta_1 = 1$. The force produced on q_1 is

$$\mathbf{F}_{21} = \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} - \frac{q_1\lambda|\mathbf{v}_1-\mathbf{v}_2|^2}{2\pi\varepsilon_0 r^2 c^2}\mathbf{r}_{21} - \frac{2q_1\lambda|\mathbf{v}_1-\mathbf{v}_2|}{2\pi\varepsilon_0 c^2 r}(\mathbf{v}_1-\mathbf{v}_2) + \frac{q_1\lambda v_1}{2\pi\varepsilon_0 r c^2}\mathbf{v}_2. \tag{2.7.3}$$

The last two terms here are not predicted by the Lorentz formula. Let us investigate more deeply the physical meaning of these terms for the case when the speed v_2 of the charge in the beam is much less than the speed of the separate charge v_1, *i.e.*, $v_1 \ll v_2$. Then the force

$$a^2\nabla\times\mathbf{D} = \frac{d^2\mathbf{G}}{dt^2}, \tag{2.7.3a}$$

But $\mathbf{r}_{21}$ and $\mathbf{v}_1$ are parallel. Therefore one obtains in this case that if $v_2 \ll v_1$ the force (2.7.3*a*) is directed along the radius and

$$\mathbf{F}_{21} = \frac{q_1\lambda(1-3\beta^2)}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21}, \tag{2.7.3b}$$

where $\beta^2 = v_1^2/c^2$. Let us note that when $v_1^2 = c^2/3$, force (2.7.3*b*) changes its sign; *i.e.*, when velocity $\mathbf{v}_1$ is big enough, repulsion of the charges of the same sign changes to attraction.

Example 4. GE Contradicts traditional predictions

Let $\lambda\mathbf{v}_2$ be a steady neutral current and let "bare" charge q_1 be at rest in the laboratory reference frame; *i.e.*, $\mathbf{v}_1 = \mathbf{a}_1 = 0$. Traditional theory predicts no force produced on q_1, but the second square bracket in (2.6.3) is nonzero, and it predicts

$$\mathbf{F}_{21} = -\frac{q_1\lambda v_2^2}{2\pi\varepsilon_0 r^2 c^2}\mathbf{r}_{21} + \frac{q_1\lambda v_2}{\pi\varepsilon_0 c^2 r}\mathbf{v}_2. \tag{2.7.4}$$

Eqs. (2.7.3) and (2.7.4) may be used for experimental testing of the proposed theory. The velocities of electrons in conductors are small. Therefore in order to test (2.7.4), it is more convenient to use a beam of rapid charges than to observe electrons' behavior in a conductor. The Coulomb force in this example is zero because one of the objects is electrically neutral.

2.8. Charged Plane

Let the plane (x_1, x_2) be charged with density σ. Generally speaking, these charges can move with velocity $\mathbf{v}_2$ and acceleration $\mathbf{a}_2$. The static part of the electric field satisfying the initial condition

$$\nabla\cdot\mathbf{E}_2|_{x_3=0} = 0, \tag{2.8.1}$$

appears as follows

$$\mathbf{E}_2 = \frac{\sigma}{2\varepsilon}, \tag{2.8.2}$$

and the electric field created by the charged plane in the vicinity of the charge q_1 is

$$\mathbf{E}_{21} = \frac{\sigma}{2\varepsilon r}\left[-\frac{\mathbf{r}_{21}\times\mathbf{v}_2}{c} + \mathbf{r}_{21}\right]. \tag{2.8.3}$$

where $\mathbf{r}_{21}$ is the radius-vector from plane (x_1, x_2) to the point nearest to the charge q_1.

In just the same way

$$\mathbf{B}_{21} = -\frac{\sigma}{2\varepsilon r c}\left[\frac{\mathbf{r}_{21}\times\mathbf{v}_2}{c} + \mathbf{r}_{21}\right]. \tag{2.8.4}$$

The formula for the magnetic field of the passive charge q_1 is preserved:

$$\mathbf{B}_{12} = \frac{q_1}{4\pi\varepsilon r^3 c}\left[\frac{\mathbf{r}_{21}\times\mathbf{v}_1}{c} + \mathbf{r}_{21}\right]. \tag{2.8.5}$$

The ε that appears in (2.8.1)–(2.8.5) is assumed to be function of space and time coordinates, $\varepsilon(x_1, x_2, x_3, t)$, and not the constant ε_0. In our case it is natural to understand ε_0 as ether density in a substance. We are interested here in the analyses of the behavior of $\varepsilon(x_1, x_2, x_3, t)$ on boundaries between two substances, and especially in the transition space between substance and free ether, or to be more accurate, in the ε gradient function near static or moving bodies. In using $\varepsilon(x_1, x_2, x_3, t)$ instead of ε_0 we aim to take into account the case when a dielectric is introduced between the charged plane and q_1. Thus we strive to investigate the cases that are explained in present-day physics by the polarization of dielectrics. The proposed theory links $\varepsilon(x_1, x_2, x_3, t)$ with different ether density in different substances, thus overcoming many problems of present-day theory of electric fields in media.

We must also take into account the fact that the magnetic constant μ_0, which has meaning of free ether compressibility, also becomes a function of space and time coordinates $\mu(x_1, x_2, x_3, t)$.

The speed of light in matter $c^2 = 1/\varepsilon\mu$ also turns out to be function of spatial coordinates.

Taking into account that $\mu = 1/\varepsilon c^2$, one obtains

$$-\nabla\left[4\pi\varepsilon r^2 c\left(\mathbf{B}_{12}\cdot\mathbf{E}_{21}\right)\right]=\frac{q_1\sigma}{2\varepsilon r}\left[\mathbf{r}_{12}+\frac{r^2\nabla\varepsilon}{\varepsilon}\right]+\frac{\mu q_1\sigma}{2r}\cdot\left\{\left[2(\mathbf{v}_1\cdot\mathbf{v}_2)-\frac{(\mathbf{r}_{21}\times\mathbf{v}_1)\cdot(\mathbf{r}_{21}\times\mathbf{v}_2)}{r^2}\right]\mathbf{r}_{21}-\mathbf{v}_1(\mathbf{r}_{21}\cdot\mathbf{v}_2)-\mathbf{v}_2(\mathbf{r}_{21}\cdot\mathbf{v}_1)\right\}+$$
$$+\frac{q_1\sigma}{2r}\left[r^2(\mathbf{v}_1\cdot\mathbf{v}_2)-(\mathbf{r}_{21}\times\mathbf{v}_1)\cdot(\mathbf{r}_{21}\times\mathbf{v}_2)\right]\nabla\mu. \tag{2.8.6}$$

A peculiarity of formula (2.8.6) is that the second item in the first square bracket and the last item depend on the distribution in space of ether mass density and compressibility. The gradient term in the first bracket predicts the appearance of force directed along the gradient of ether density. Therefore a dielectric plate is drawn into capacitors: ether density ε_0 in a hollow capacitor is bigger than ε in dielectric. This force grows with r: distance of q_1 from the charged plane. In the case of a capacitor, this means that force is bigger when the dielectric plate is thicker.

These effects are observed only when the charges are "bare". It is well known that when a dielectric is brought between capacitor's plates, its capacity is enlarged or, which is the same, the strength of attraction between plates is lowered. What is the cause of this effect?

Today this effect is explained by "polarization of the dielectrics". It is believed that molecular dipoles are shifted as a reaction to the external field action. Such a shift partly neutralizes the charge on the plates and thus weakens the Coulomb force.

Let us investigate this problem in greater detail, returning to the views of the physicists of the XIXth century, and discussing Eichenwald's experiments. As was mentioned in Section 2, those experiments are believed to disprove Hertz electrodynamics, which include total time derivatives. At that time physicists believed that ether polarization between the capacitor plates led to the observed effects. They often spoke about one Eichenwald's experiment, although he set up a lot of different experiments, and many conclusions were deduced from his experiments. We shall consider some of them referring to our discussion.

In the first experiment, round capacitors plates were rotated. The induced magnetic field was measured. The experiment showed that such movement of electrons creates the same magnetic field as their movement in a conductor.

In the second experiment, the same capacitor with dielectric between the plates was rotated. Such rotation created the same magnetic field as in the first experiment, *i.e.*, the same as without dielectric.

In the third experiment, the capacitor plates were immovable, but the dielectric was rotated. Such rotation also induced a magnetic field. Its direction did not change when the rotation direction changed, but it did change when the plates were charged oppositely.

Let us consider the conclusions that were drawn from these experiments. These conclusions were incorporated into the foundation of modern physics.

There was also another question that excited physicists at that time. This was the problem of the physical meaning of the displacement current introduced by Maxwell into his equations in addition to conductivity current. Displacement current was mathematically realized as the electric field partial time derivative. Displacement current was used to explain the fact that the magnetic field does not end on one of the capacitor's plates, but overcomes the space between plates even though electrons do not travel from one plate to the other.

The following explanation was proposed. Ether particles between the plates are polarized by the electric field and displaced. This polarization creates in the ether the conductivity that is manifested as the electric field partial time derivative.

It is interesting that present-day physics denying ether actually preserves this explanation just as the very name of the current. And today it becomes completely inexplicable that electric field changes independently of space coordinates, and dependence on time manifests only between capacitor plates, and does not manifest along conductors and in substance.

But let us return to Eichenwald's first experiment. If such a polarization of the ether particles takes place, it must lessen the charge on the plates, and correspondingly the magnetic field created by rotating the capacitor should be less than the magnetic field created by a conductivity current. But the experiment showed complete equivalence of these fields.

Eichenwald himself [17], and some other scientists, interpreted this fact as stability of ether and its polarized particles: the capacitor's rotation does not carry them along.

It is impossible to understand today how Eichenwald could come to such a conclusion. Certainly it is difficult to come to any conclusion about behavior of such a substance as exotic as ether on the basis of only one experiment, and Eichenwald's second experiment shows that ether contained in dielectric is carried along, but the effect remains.

In one way or in another, Eichenwald supported Lorentz' theory of stable ether and declared that his experiment refutes Hertz's idea of moving ether. Today one can hear for the very same experiment an interpretation very different from its interpretation by Eichenwald. Many educated persons assert that Eichenwald showed that it is prohibited to use total time derivatives in electrodynamics. Some very educated persons, for instance [17], believe that Eichenwald proves ether nonexistence, but that total time derivatives in electrodynamics are necessary.

Let us consider Phipps' monograph [17] in greater detail. I recommend the reader to read this book if possible. This is sum total of many years of meditation on electrodynamics problems written by a very clever man with very keen insight. Therefore his even erroneous, as we believe, ideas characterize the scatter coefficient in the interpretation of Eichenwald's experiments.

Dr. Phipps is a supporter of the idea of introducing total time derivatives into Maxwell equations. He scrupulously investigates how Hertz did this [17, p. 24]: "He (Hertz) conceived of his theory…as describing an electrodynamics of "moving media," and interpreted his new velocity parameter (appearing in total

time derivative) as ether velocity. This was a serious mistake, a false interpretation. He compounded that error by postulating Stokesian ether 100% convicted by ponderable matter. This made his theory testable, because it reified the ether – giving it "hooks" to observable matter…Soon after Hertz death an experimentalist, Eichenwald went into his laboratory and disconfirmed Hertz's predictions. The invariant theory was thus discredited and relegated to history's trash bin."

Such an understanding of Eichenwald's experiments leads Dr. Phipps to negation of ether altogether, and to his semi-relativistic theory, although, we repeat, he insists on total time derivatives in electrodynamics.

We here cite Dr. Phipps only to illustrate that Eichenwald's experiment can be interpreted very differently, and to propose our own interpretation. First of all, let me express my deep conviction that the main problem of experimental physics during this millennium will be ascertaining the qualities of ether. Therefore, we cannot be completely certain in declaring its qualities today. Nevertheless, we have some foundation for some conclusions.

We cannot say for sure if ether is carried along in the first experiment. But we are sure that ether in dielectric is carried along with it, because the dielectric's ether density ρ and compressibility μ are not changed. And this urges us to the conclusion that ether is carried along in the first experiment as well.

But the most interesting point for us here is that, in contrast to Mr. Phipps interpretation, we need total time derivatives in electrodynamics not only to describe ether movement, but also to describe conductivity current without having to introduce it axiomatically. And the main result of their usage is introduction of the curl current [second item in Eq. (2.2.6*a*)]. This current moves in the conductor as well, and not with the speed of electrons, but with the speed of light. Therefore, a knife-switch switched on in Europe lights a lamp in America immediately, and not some years later when electrons arrive there over a cable.

Just this curl current overcomes the space between the capacitor plates and extends, moving along the conductor, carrying electrons along and creating magnetic field. Just this curl current is responsible for all the effects attributed to current nowadays. Just this curl current induces ether rotation in the dielectric while electrons cannot penetrate dielectric. And the electrons' movement in conductor is rather a consequence of curl current in the same way in which sand's movement in river is a consequence of water movement in it.

Let us note that a partial time derivative cannot be a cause for current to overcome space between capacitor's plates, just because there is no time dependence in the changes of the fields between capacitor's plates, in comparison with the fields in a conductor. These changes depend only on space coordinates.

But let us return to the second of Eichenwald's experiments, where the capacitor rotates together with the dielectric, and correspondingly the ether filling the dielectric also rotates. We need more accurate consideration of this experiment because modern physics, in this case not hindered by disbelief in ether, accurately reproduces for the dielectric the ideas of the XIX$^{\underline{th}}$ century concerning ether.

They already did not speak about polarization of ether particles, but rather attributed this idea to molecules. They believed that charges in the dielectric are shifted, and the shift enlarges the capacitance, and partly neutralizes the charges on the capacitor plates, thus lessening attraction between them.

But why does the dielectric influence the capacitance? And what is the essence of capacitance? And is capacitance linked with polarization of the dielectrics? And why doesn't this shift neutralize all the charges on the capacitor plates?

They usually answer that there are not enough dipoles in dielectric. But if so, when there are a small number of charges on the plates, for which there are enough dipoles in dielectric, all such charges should be neutralized. But experience does not show such an effect. Coulomb's force is just lessened in $\varepsilon/\varepsilon_0$ times, either for a small or for a large amount of charges. And let us note that direct measurements to determine the shift of dipoles in the dielectrics were not produced, to the best of this author's knowledge.

What explanation for the corresponding experiments can be proposed? Let us begin with capacitance. It was mentioned that the physical meaning of free ether dielectric permeability ε_0 is free ether mass density. Correspondingly, we interpret absolute dielectric permeability ε as ether density in dielectric. This means that the introduction of dielectric between the capacitor plates just changes the ether density between them. Correspondingly, the Coulomb force is lessened: it depends not only on the value of charges but also on the quality of the substance filling the space separating them. Therefore, the dielectric between plates does not influence the magnetic field of the rotating capacitor: its introduction conserves charges on the plates. Thus we could predict the result of the second Eichenwald's experiment.

And what is the physical meaning of the capacitance? If C is the capacitance, d is the distance between the plates, and A is the area of the plates, then

$$C = \frac{\varepsilon A}{d},$$

i.e., the capacitance is the average surface mass density of the ether in the dielectric.

What other effects detected in Eichenwald's experiments does formula (2.8.6) predict? Ether density between the capacitor plates does not change. This means that Coulomb force is ε_0 inverse in the first experiment and ε inverse in the second one, although charges on the plates are conserved. Ether densities ε_0 and ε are constant, and therefore the second item in the first square bracket in (2.8.6) is zero, because $\nabla\varepsilon = 0$.

The velocities of the charges on the plates are parallel. These velocities are perpendicular to the radius vector. This means that only radial force remains in braces. This force is μ proportional; *i.e.,* it is v^2/c^2 weaker than the Coulomb force, but is co-directed with it and enlarges it. Eichenwald did not measure it, but it would be interesting to produce the corresponding experiment and answer the question: "Is it correct that the attraction force between rotating plates of a capacitor is greater than between stable ones?"

We have analyzed the effects predicted by the first item in Eq. (2.8.6). The physical meaning of the third, gradient item in (2.8.6) (the second square brackets in braces is analogous to the

physical meaning of the gradient item in the static part. But it is linked with another ether characteristic: its compressibility. We observe its action when paramagnetics are pulled in and diamagnetics are pushed out of a solenoid. The force is directed along the gradient of the ether compressibility μ, which increases from the solenoid's ends to its midpoint. The static gradient part is also directed along the gradient of ε. This force always expels dielectric from free ether because ε_0 is always less than the ether density in substance. But in the case of a capacitor, charges of opposite sign are induced on its plates. Therefore $\nabla\varepsilon$ is directed into the capacitor.

Current in the solenoid's coils are induced by charges of the same sign. And ether compressibility in different substances can be bigger than in free ether (paramagnetics), or smaller (diamagnetics). Therefore, paramagnetics are pulled into, and diamagnetics are pushed out of, the solenoid.

What does the first Eichenwald's experiment shows us in this respect? Let us note that square brackets in the third item in (2.8.6) is always positive because $\mathbf{v}_1$ and $\mathbf{v}_2$ (tangential velocities of the charges on the rotating plates) are co-directed. Charges opposite sign are induced on the plates. Therefore the third item produces force directed against $\nabla\mu$, *i.e.,* in the direction of magnetic field decrease.

Charges' velocities increase along the radius of the plates, but magnetic fields may overcross each other. Therefore, we cannot assert that the magnetic field also increases along the radius. This should be determined by experiment. But we can assert that paramagnetics will be pulled into the capacitor, and diamagnetics pushed out of it, if the magnetic field inside the capacitor increases along the radius. The sign of the assertion is opposite in the opposite case. It is also opposite if the charges on the plates are of the same sign. In the last case, a picture similar to that of solenoid is predicted.

We observe here just an accurate analog to the electric field. Rotation of two plates charged with the charges of the same sign will induce a traditional effect: diamagnetics will be pushed out and paramagnetics pulled in.

Let us formulate the main result of our consideration of formula (2.8.6). Although apparently a certain polarization of dielectrics in capacitors takes place, the main effects are determined by the fall of ether mass density ε and ether compressibility μ on the boundary between different materials, or free-space ether and ether in substance

If the charged plane is immovable, then the following correlations are valid:

$$\mathbf{r}_{21}\perp\mathbf{v}_2,\ \mathbf{r}_{21}\perp\mathbf{a}_2,\ \textit{i.e.,}\ \left(\mathbf{r}_{21}\cdot\mathbf{v}_2\right)=0,\ \left(\mathbf{r}_{21}\cdot\mathbf{a}_2\right)=0.$$

In this case (2.8.6) grows simpler

$$-\nabla\left[4\pi\varepsilon r^3 c\left(\mathbf{B}_{12}\cdot\mathbf{E}_{21}\right)\right]=\frac{q_1\sigma}{2\varepsilon r}\left[\mathbf{r}_{12}+\frac{r^2\nabla\varepsilon}{\varepsilon}\right]+\frac{\mu q_1\sigma}{2r}\left[2\mathbf{r}_{21}(\mathbf{v}_1\cdot\mathbf{v}_2)-\mathbf{v}_2(\mathbf{r}_{21}\cdot\mathbf{v}_1)\right]. \tag{2.8.7}$$

We have calculated the Huygens part of the force. The Newton part appears as follows:

$$\begin{gathered}\frac{d}{dt}\left[4\pi\varepsilon r^3 c\left(\mathbf{B}_{12}\times\mathbf{B}_{21}\right)\right]=\frac{q_1\sigma\mu}{2r}\Big[-\mathbf{r}_{21}\left(\mathbf{v}_1-\mathbf{v}_2\right)^2+\left(\mathbf{v}_1-\mathbf{v}_2\right)\left(\mathbf{r}_{21}\cdot\left(\mathbf{v}_1-\mathbf{v}_2\right)\right)-\\ -\mathbf{r}_{21}\left(\mathbf{r}_{21}\cdot\left(\mathbf{a}_1-\mathbf{a}_2\right)\right)-\left(\mathbf{a}_1-\mathbf{a}_2\right)r^2\Big]+\frac{q_1\sigma}{2r}\frac{d\mu}{dt}\left[\mathbf{r}_{21}\left(\mathbf{r}_{21}\cdot\left(\mathbf{v}_1-\mathbf{v}_2\right)\right)+\left(\mathbf{v}_1-\mathbf{v}_2\right)r^2\right].\end{gathered} \tag{2.8.8}$$

The static part is absent from this formula, and consequently force depending on ε gradient is absent as well. The whole part depends not on velocities' product but on their difference product. Therefore it is null in the first and the second Eichenwald experiments: the plates' velocities are modulo equal and codirected. Let us suppose the following modification of the second Eichenwald experiment: capacitor's plates uniformly rotate in opposite directions around dielectric. Radius-vector in such experiment is perpendicular to velocities. Therefore all the items containing $(\mathbf{r}_{21}\cdot(\mathbf{v}_1-\mathbf{v}_2))$, all the item containing accelerations and the last item in (2.8.8) will be zero. Only radial force is preserved in (2.8.8). Thus Newton's part of force density

$$\mathbf{F}_N=-\frac{4\sigma^2\mu v^2}{2r}\mathbf{r}_{21}. \tag{2.8.9}$$

The velocities in the experiment are oppositely directed. Therefore the braces in (2.8.6) for the case will appear as follows

$$\mathbf{F}_H=-\frac{\sigma^2\mu v^2}{2r}\mathbf{r}_{21}, \tag{2.8.10}$$

i.e., for this case, Huygens' and Newtons' surface force density are directed against the Coulomb surface force density, and the sum surface force density appears as follows:

$$\mathbf{F}_N+\mathbf{F}_H=-\frac{5\sigma^2\mu v^2}{2r}\mathbf{r}_{21}. \tag{2.8.11}$$

Below we shall use term "force" instead of "surface force density" to simplify the narration.

The forces defined by the second and the fourth square brackets are c times less than the other forces here. They could be essential in the processes combined by the idea of "electroweak interaction". They need special investigation, which we postpone. Let us investigate the force defined by the third square bracket. Its coefficient depends on time derivative of μ, *i.e.,* ether compressibility in dielectric. We can detect this force if, for instance, we put a substance with periodically changing ether compressibility among oppositely rotating plates of a capacitor. Let

$$\mu=\mu_0\cos\omega t, \tag{2.8.12}$$

i.e.,

$$\frac{d\mu}{dt} = -\omega\mu_0 \sin\omega t. \tag{2.8.13}$$

Here μ_0 is average ether compressibility in the substance, ω is frequency.

Then the force appearing between the capacitor plates because of μ changing in time and acting from plate 2 on plate 1 is

$$\mathbf{F}_{21} = \sigma^2 \omega\mu_0 r \sin(\omega t)\mathbf{v}_1. \tag{2.8.14}$$

This force is proportional to square surface charges density σ on the plates and linear on ω, μ_0, r; *i.e.*, it increases with increase of these parameters. It periodically untwists and brakes plate 1 in accordance with the sin law. The force with which plate 1 acts on plate 2 is:

$$\mathbf{F}_{12} = -\mathbf{F}_{21}, \tag{2.8.15}$$

Plate 1 acts on plate 2 in the same way.

Let us consider an additional modification of this experiment: the dielectric does not rest between oppositely rotating plates, but rotates with one of them. In this case, μ does not depend on time explicitly, but, generally speaking, the convective part of the total time derivative $(\mathbf{v}_1 \cdot \nabla)\mu$ is not null. Under what conditions? Apparently when tangential velocity $\mathbf{v}_1$ and $\nabla\mu$ are not perpendicular. Is this condition valid for this case? Perhaps not. Note that in the static case $\nabla\mu$ is apparently directed perpendicular to the dielectric surface. We know too little about ether qualities to assert something with certainty. But we can adopt the following:

Assumption: $\nabla\mu$ near the surface of a rotating dielectric is directed along tangential velocity, *i.e.*, μ increases in this direction.

The adopted assumption means that total time derivative convective part $(\mathbf{v}_1 \cdot \nabla)\mu$ is always positive and does not depend on the direction of the dielectric rotation. The force with which the plates act on each other

$$\mathbf{F}_{21} = \frac{1}{2}\sigma^2 r(\mathbf{v}_1 \cdot \nabla)\mu\mathbf{v}_1, \tag{2.8.16}$$

$$\mathbf{F}_{12} = -\mathbf{F}_{21} = \frac{1}{2}\sigma^2 r(\mathbf{v}_2 \cdot \nabla)\mu\mathbf{v}_2. \tag{2.8.17}$$

Let us return to the third Eichenwald experiment. In this experiment the capacitor plates were at rest, and only an ebonite disc rotated. Sudden for Eichenwald and expected for us was that the magnetic field direction did not depend on the rotation direction. Eichenwald himself explained this by invoking qualities of ebonite. We are sure that it is really the ether qualities: when ether jumps from its more dense state in dielectric into its more rarefied state in free space, the rotation movement drags it. Therefore, its compressibility gradient vector is directed along the tangential velocity vector, and their scalar product is always positive.

The last two items here are non-zero if μ and ε depend on time. The previous items are consequences of general formulas (2.4.1)–(2.4.3). The general formula is the sum of the Huygens and Newton forces

$$\mathbf{F}_{21} = \mathbf{F}_H + \mathbf{F}_N. \tag{2.8.18}$$

2.9. Fields That Exist Inside a Charged Sphere

Our aim in this Section is to find force that acts on charge q_1 inside sphere of radius R_0 charged with density σ. The initial condition

$$\nabla \cdot \mathbf{E}_2 = \frac{4\sigma r}{\varepsilon_0 R_0^2},\ r = R_0 \tag{2.9.1}$$

supplies us with the static part of the field inside the sphere

$$\mathbf{E}_2 = \frac{\sigma r}{\varepsilon_0 R_0^2}\mathbf{r}_{21},\ r \le R_0. \tag{2.9.2}$$

One can see that the field (2.9.2) is proportional to r^2; *i.e.*, it decreases to zero when r decreases to zero. This means that the field is not constant and not zero, as is believed nowadays, because "electric field" is defined as "a force acting on a charge". It has been said already that such a definition is not satisfactory. Does this mean that our conclusion contradicts well-known experimental facts? We shall see below that there is really no force acting on a charge inside a charged sphere in the static case, but not because there is no field inside the sphere, but rather because the interaction energy inside such a sphere is constant, and therefore its gradient is zero.

If the charges on the sphere move with velocity $\mathbf{v}_2$, they create the following field at the point where charge q_1 is situated:

$$\mathbf{E}_{21} = \frac{\sigma r}{\varepsilon_0 R_0^2}\left[-\frac{\mathbf{r}_{21} \times \mathbf{v}_2}{c} + \mathbf{r}_{21}\right],\ r \le R_0. \tag{2.9.3}$$

In just the same way

$$\mathbf{B}_{21} = -\frac{\sigma r}{\varepsilon_0 R_0^2 c}\left[\frac{\mathbf{r}_{21} \times \mathbf{v}_2}{c} + \mathbf{r}_{21}\right],\ r \le R_0. \tag{2.9.4}$$

The magnetic field created by moving charge q_1 is traditional:

$$\mathbf{B}_{12} = \frac{q_1}{4\pi\varepsilon_0 r^3 c}\left[\frac{\mathbf{r}_{21} \times \mathbf{v}_1}{c} + \mathbf{r}_{21}\right],\ r \le R_0. \tag{2.9.5}$$

The Huygens force acting on q_1 inside the sphere is

$$-\nabla[4\pi\varepsilon_0 R_0^3 c(\mathbf{B}_{12} \cdot \mathbf{E}_{21}) = \frac{q_1 \sigma R_0}{\varepsilon_0 r c^2}[\mathbf{r}_{21} v_1 v_2 (\cos\theta_3 + \cos\theta_1 \cdot \cos\theta_2) - \mathbf{v}_2 v_1 r \cos\theta_2 - \mathbf{v}_1 v_2 r \cos\theta_1],\ r \le R_0. \tag{2.9.6}$$

Here θ_1 is the angle between radius vector $\mathbf{r}_{21}$ and velocity $\mathbf{v}_1$, θ_2 is the angle between $\mathbf{r}_{21}$ and $\mathbf{v}_2$, θ_3 is the angle between $\mathbf{v}_1$ and $\mathbf{v}_2$.

This force acts on q_1 from every point of the charged sphere. Let us note that the Coulomb force is absent: its contribution into the interaction energy between the charge and the sphere is constant, and so its energy gradient is zero.

This example shows the problems of the present-day understanding of the electric field as force acting on a charge. Such a definition compels us to believe that the field inside the sphere is zero. Because the field exists outside the sphere, it must be discontinuous at the surface of the sphere. And what is going on at the surface of the sphere? And will any force act on a charge moving inside a static charged sphere?

Let us demonstrate that we can obtain reasonable answers on all these questions within the framework of the proposed approach. Charge density on the sphere is $\sigma = \dfrac{q_2}{4\pi R_0^2}$, where q_2 is the common charge of the sphere. Having integrated over the sphere, we obtain from (2.9.2)

$$\mathbf{E}_2\big|_{r=R_0} = \frac{q_2}{4\pi\varepsilon_0}. \tag{2.9.7}$$

And without any discontinuity,

$$\mathbf{E}_2 = \frac{q_2}{4\pi\varepsilon_0 r^2}, \quad r \ge R_0. \tag{2.9.8}$$

Let us return to Eq. (2.9.6). It does not exhaust the forces acting on charge inside the sphere. In addition we must find the Newtonian part of the force; *i.e.,* the time derivative of the vector product of the magnetic fields:

The coefficient before the square bracket in Eq. (2.9.6) can create the impression that the force is proportional to the sphere radius R_0. But charge density σ is R_0^2 inverse; therefore, the force (2.9.6) is R_0 inverse. All the terms in the square bracket depend on the product of the velocities of charges on sphere and the charge inside the sphere. Therefore the whole force is zero if at least one of the charges is at rest. The radius vector inside the square bracket links any charge on the sphere with the charge q_1 inside. This bracket coefficient radius vector is modulo inverse, *i.e.,* the whole force does not depend on the distance between q_1 and particular charges on the sphere. But it essentially depends on the angles between the radius vector and the charges' velocities and on the angle between velocities of the charges on the sphere and q_1.

Usually we are interested not in the interaction force between q_1 and any particular point on the sphere. We usually want to understand how the whole sphere influences q_1. In this case we must integrate (2.9.6) over the whole sphere.

Let us find Newton's force in our case:

$$\frac{d}{dt}\left[4\pi\varepsilon_0 R_0^3 c(\mathbf{B}_{12}\times\mathbf{B}_{21})\right] = \frac{q_1\sigma R_0}{\varepsilon_0 r c^2}\left\{\mathbf{r}_{21}\left[|\mathbf{v}_1-\mathbf{v}_2|^2(1-\cos\theta_4)\right] + \left[\mathbf{r}_{21} r|\mathbf{a}_1-\mathbf{a}_2|\cos\theta_5 - (\mathbf{a}_1-\mathbf{a}_2)r^2\right]\right\}, \quad r \le R_0. \tag{2.9.9}$$

Here θ_4 is the angle between $\mathbf{r}_{21}$ and $(\mathbf{v}_1 - \mathbf{v}_2)$, θ_5 is the angle between $\mathbf{r}_{21}$ and $(\mathbf{a}_1 - \mathbf{a}_2)$. One can see that the velocity-dependent part of the formula does not depend on the distance from q_1 to the points on the sphere, but the acceleration dependent part increases with this distance. This force is not zero even if the charges on the sphere or q_1 are at rest.

Let us consider the case of stable current on the sphere and constant velocity of q_1; *i.e.,* we put to zero the second square bracket in (2.9.9). The angle between $\mathbf{r}_{21}$ and $(\mathbf{v}_1 - \mathbf{v}_2)$ is never null for any movement of q_1, *i.e.,* $\cos\theta_4$ is never equal to 1. This means that radial force directed from sphere must be observed because $(\mathbf{v}_1 - \mathbf{v}_2)^2$ and $(1 - \cos\theta_4)$ are always positive. In other terms, there is a magnetic field inside the charged sphere. This contradicts the well-known theorem that magnetic field circulation over a curve not enveloping current is zero. The cause is that present-day electrodynamics does not take into account the curl current [Eq. (2.2.6*a*)] and the radial part of magnetic field [Eq. (2.2.4)]. Formula (2.9.4) shows that in a charged sphere, magnetic field decreases as r^2 to the center of the sphere, and is directed from this center to the sphere along the radius. Concentric spheres are level surfaces of the field. This field exists even if the charges on the sphere are at rest: the static part of (2.9.4) and magnetic field of moving charge q_1 interact and create observable effects contradicting present-day theory. The general formula of force acting on q_1 inside charged sphere appears as follows

$$\begin{aligned}\mathbf{F}_{21} = \frac{q_1\sigma R_0}{\varepsilon_0 r c}\Big\{&\mathbf{r}_{21}\left[|\mathbf{v}_1-\mathbf{v}_2|^2(1-\cos\theta_4) + v_1 v_2\cos\theta_1\cos\theta_2\right] - \\ &-\mathbf{v}_1 r v_2\cos\theta_2 - \mathbf{v}_2 r v_1\cos\theta_1 + \left[\mathbf{r}_{21} r|\mathbf{a}_1-\mathbf{a}_2|\cos\theta_5 - (\mathbf{a}_1-\mathbf{a}_2)r^2\right]\Big\}.\end{aligned} \tag{2.9.10}$$

In particular when the charge q_1 inside the sphere is at rest, *i.e.,* when $\mathbf{v}_1 = 0$, $\mathbf{a}_1 = 0$

$$\begin{aligned}\mathbf{F}_{21} = \frac{q_1\sigma R_0}{\varepsilon_0 r c^2}\Big\{&\left[\mathbf{r}_{21}|\mathbf{v}_2|^2(1-\cos\theta_4)\right] + \\ &+\mathbf{a}_2 r^2 - \mathbf{r}_{21} r|\mathbf{a}_2|\cos\theta_5\Big\}.\end{aligned} \tag{2.9.11}$$

If the charges in and on the sphere are immovable, (2.9.10) is zero. There is an electric field inside the sphere but there is no force acting on the charge.

Let us illustrate (2.9.10) by the example of when direct current is brought to a diameter end of the sphere (the first pole) and drawn aside from the other end of the diameter (the second pole). The current flows over the sphere between these points. How will force lines look?

Present-day physics asserts that the circulation of the magnetic field over a curve that does not envelop the current is zero. But formula (2.9.10) predicts that a force acts on a charge in our case; *i.e.*, it predicts a magnetic field inside the sphere. Not going into mathematical details, I just pinpoint the cause of this contradiction. The cause is that Eq. (2.1.9) contains only conductivity current, and does not contain curl item $\nabla\times(\mathbf{E}\times\mathbf{v})$ that appears in Eq. (2.2.6*a*). Just this item creates a magnetic field and a corresponding force (2.9.11) inside the sphere.

The magnetic field (2.9.4) is proportional r^2, *i.e.*, the squared distance from any point on the sphere to the point inside it. It is minimal and equal to zero when $\mathbf{r}_{21}\perp\mathbf{v}_2$; *i.e.*, it is minimal at the center of the sphere. It increases along the radius. Small spheres with centers coinciding with the center of the big one are level curves for magnetic field created by current over the sphere. The magnetic field comes to maximum on the big sphere; *i.e.*, it enlarges with the distance from the big circumference center.

The situation with the force is different. Formula (2.9.10) shows that it does not depend on the distance from the sphere, but rather essentially depends on the angle between velocities and the radius vector from points on the surface to the point inside (we assume acceleration equal to zero). One force is radial. It depends on squared difference between velocities of the charge on the surface and inside, the product of these velocities, and angles between the radius vector and these velocities. The second force is directed along velocities. If the charge inside is at rest, the force is proportional v_2^2, and is maximal at the center, where $\cos\theta_2 = 0$ because $\mathbf{r}_{21}\perp\mathbf{v}_2$ there.

2.10. Energy, Impulse, Force Momentum

Let us clear up mechanical qualities of the two-charges system under consideration. Let us emphasize that (2.4.1)–(2.4.3) suppose that external forces which induce charges' velocities and accelerations acts on the system. Formulas for $\mathbf{F}_{12}$ and $\mathbf{F}_{21}$ contain non-central terms, and therefore classical mechanical theorems cannot be transferred directly on the system under our consideration. The aim of this section is to show that all these theorems are valid in our case as well.

The principle force vector

$$\mathbf{F}_{int} = \mathbf{F}_{12} + \mathbf{F}_{21} \equiv 0. \tag{2.10.1}$$

Integrating this identity with respect to time and along an arbitrary trajectory in space, one obtains

$$\int_A \mathbf{F}_{int}\,dt = \text{const}, \tag{2.10.2}$$

$$\int_B \mathbf{F}_{int}\,dx = 0. \tag{2.10.3}$$

Equalities (2.10.2) and (2.10.3) imply the validity of two theorems:

Theorem 1. Internal forces do not change the system impulse.

Theorem 2. Internal forces do not produce work.

Let us find the moment of internal forces. Let O be an arbitrary point in space, $\mathbf{r}_1$ be radius vector from O to q_1 and $\mathbf{r}_2$ be radius vector from O to q_2. The internal forces' principal moment with respect to O is

$$\begin{aligned}\mathbf{M}_{int} &= \mathbf{r}_1\times\mathbf{F}_{21} + \mathbf{r}_2\times\mathbf{F}_{12} = (\mathbf{r}_1-\mathbf{r}_2)\times\mathbf{F}_{21} = \\ &= (\mathbf{r}_2-\mathbf{r}_1)\times\mathbf{F}_{12} = \mathbf{r}_{21}\times\mathbf{F}_{21} = \mathbf{r}_{12}\times\mathbf{F}_{12}.\end{aligned} \tag{2.10.4}$$

Eq. (2.10.4) implies the validity of:

Theorem 3. A moment of force transferred to the system by external forces does not depend on the point of its application, and creates two moments of force acting on the charges. These moments are modulo equal and codirected. They can be considered as a force couple applied to radius vector.

The notion of "force couple" is used in mechanics to describe solid body movement. It determines solid body rotation if the couple arm is not zero. Zero occurs only if the forces in the couple are directed along lines that are not just parallel, but *identical*. Only the special case of a zero couple does not influence solid body movement.

We can interpret theorem 3 as application of the force couple idea to radius vector, or to be more accurate to its ends. This force couple not only rotates the radius vector, but also deforms it: expands or compress it when the forces are directed along the same straight line. Just this case corresponds radial forces. This means that in our case, a force couple with zero arm also has understandable physical meaning.

Charges are situated on the ends of a radius vector. Thus we come to the connection between theorem 3 and Newton's third law in mechanics.

It is widely accepted that the assertion that action and counteraction forces are directed oppositely means that they are directed along the same straight line. The author has heard such assertions from mechanics professors. Therefore, they believe that all non-radial forces cannot satisfy Newton's third law. They assert that, for instance, the Lorentz force formula cannot satisfy Newton's third law because it contains a non-radial term (look for instance in [10]). Certainly when we speak about point-like masses, we have no other choice. But the situation essentially changes when we speak about real physical bodies.

It was mentioned in Section 1 that all the forces in XVIII and XIX century physics were radial. This tradition comes to us as we see. But it is difficult to agree with such an understanding of Newton's third law. If that understanding were correct, then, for instance, the billiard game could not exist. The passive ball would just continue the trajectory of the active one, not changing it. In other words, such an understanding for interaction of mechanical bodies leaves only head-on collision, and excludes oblique collisions.

At first I thought that theorem 3 generalized the third Newton law for general electrodynamics. But recently I read its formulation in a textbook [21]. The author Putilov just stresses that in general the action and counteraction forces in the third Newton law are directed along parallel straight lines. As an example, he proposes interaction of "magnetic poles". Thus we can assert now that theorem 3 just corroborates validity of Newton's third law in general electrodynamics.

But the very law should be formulated as follows: in collisions of real mechanical bodies, action and counteraction moments of force are modulo equal and co-directed.

Example 1.

Let us find the force moment produced on the charge in example 3 of Section 5. The force $\mathbf{F}_{21}$ is defined by (2.5.6)

$$\mathbf{r}_{21}\times\mathbf{F}_{21}=\frac{-2q_1q_2\upsilon\cos\theta}{2\pi\varepsilon_0 r^2c^2}(\mathbf{r}_{21}\times\mathbf{v})=\mathbf{r}_{12}\times\mathbf{F}_{12}. \qquad (2.10.5)$$

Eq. (2.10.5) means that both arms work the same.

Example 2.

Let us find the force moment produced on the charges in Example 3 of Section 7. The force $\mathbf{F}_{21}$ is defined by (2.7.3).

$$\begin{aligned}\mathbf{r}_{21}\times\mathbf{F}_{21}&=\frac{q_1\lambda\upsilon_1}{2\pi\varepsilon_0 rc^2}\big[(\mathbf{r}_{21}\times\mathbf{v}_2)-\\&-\big(\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2)|\mathbf{v}_1-\mathbf{v}_2|\big)\big]=\mathbf{r}_{12}\times\mathbf{F}_{12}.\end{aligned} \qquad (2.10.6)$$

Only the first equality here is valid in accordance to Lorentz force, *i.e.,* only one arm works if we limit ourselves with present-day electrodynamics.

The Lorentz force predicts appearance of not only radial force, but also force directed along velocity as well; *i.e.,* mechanically it describes oblique impact, but predicts rotation of only one of the interacting bodies, and not of the second one.

2.11. Summary of Argument

Let us briefly repeat the main points to which we have come above:

1. Certain generalizations of the traditional Maxwell equations have been proposed here. The new aspects of these generalizations are:

1.1. The divergence of the magnetic field is assumed to be non-zero; *i.e.,* the existence of magnetic charge is accepted. But such charge does not coincide with Dirac's monopole in many aspects. It is closely connected with the magnetic moment of the electrically charged particles, and in this sense it may be considered as another incarnation of the electric charge. But in contrast to electric charges, no force similar to the Coulomb one appears between two magnetic charges at rest. They begin interact only in motion.

1.2. Total time derivatives instead of the partial ones are used in the equations. Physically this means that we can take into account the ether, *i.e.,* the medium in which electromagnetic waves propagate. For this, the direct current that is introduced into the traditional Maxwell equations "by hand" turns out to be one of the two items forming the convective part of the total time derivative. The second part of it is a curl expression that appears when an electric wave is described, and which was not explicitly a subject of investigation in the Maxwell system.

Mathematically, this means that the generalized Maxwell system is Galileo invariant, and we do not need to use Lorentz transformations: the total time derivatives take it into consideration automatically. In addition, the generalized Maxwell equations have a good mathematical peculiarity: in contrast to traditional equations, they have solution in the case of "bare" charge.

2. The last mathematical peculiarity of the Generalized Maxwell equations enables us to propose some new approaches to the concepts of the fields and their interaction.

2.1. Fields are defined not in terms of force acting on a charge, but rather just as a solution of the Generalized System. It is shown in Appendix 1 that the electric field has the mechanical dimension of velocity, and the magnetic field is non-dimensional and means rotation angle.

2.2. Thus we turn out to be able to describe the interaction between charges with the help of interaction between fields induced by these charges. Interaction energy and interaction impulse are constructed with the help of the fields. The gradient of interaction energy supplies us with the Huygens part of the force, and the time derivative of the interaction impulse gives us the Newtonian part of it. The formula obtained describes all the experimental results known to the author.

3. Some examples are investigated.

3.1. A case usually investigated nowadays within the framework of Relativity theory is examined. An alternative formula is proposed.

3.2. A peculiarity of the interaction between two electrically charged beams is investigated. The existence of a "cluster effect" is predicted.

3. Mechanical Dimensions in Electrodynamics, Electron Construction and Plank's Constant

Today theoretical physics uses many systems of units differing by main units' dimensions of physical value. This leads to different writing for equations describing identical processes. There are more than dozen widely used different systems and many authors prefer to use systems of their own. This increases their number to some dozens.

Many compilations appear in electric and magnetic investigations because of different systems' usage. For instance the following four values: electric field strength, magnetic field strength, electric displacement and magnetic induction have the same dimension. Such physical value as electric charge magnetic mass electric displacement flow magnetic flow have identical dimension in Gaussian CGS system as well.

Frivolity in dimension systems' construction leads to situation when ε (vacuum permittivity) and μ (vacuum permeability) have zero dimensions in Coulomb law, *i.e.,* symbol ε from CGSE system and symbol μ from CGSM system are thrown out. Thus we obtain that electromagnetic values have different dimension in CGSE and CGSM systems [22].

3.1. Systems of Units

Gauss C.F. was the father of today dimensions' system. In 1832 he supposed in his paper "Intensitas vis magneticae terrestris ad mensuram absolutam revocata", that dimensions at all physical characteristics can be established if only some main physical values are defined. Taking into account Pythagorean principle of triadal description of unity Gauss took dimensions of triad "space (L) – mass (M) – time (T)" as fundamental one.

William Thompson (Lord Kelvin) continued elaborating LMT Gauss "absolute system" in 1860's. His CGS system is also used today. In 1881 International Congress of electricians adopted common unity system for electric and magnetic measurements. It was adopted that electric and magnetic units was not possible to express with the help of initial concepts (meter, kilogram, second) which were sufficient for mechanics.

Therefore seven units: second, kilogram, meter, Ampere, Kelvin, mole, candela were adopted as initial. They are believed to be fundamental and incapable to be expressed with the help of each other.

These authors cannot agree with such assertion. In our everyday work we often observe in electrodynamics their accurate mechanic analog. The aim of this article is to express Ampere in mechanic terms. This will help us to explicitly formulate connections between electricity and mechanics.

3.2. Mechanic System of Units in Electrodynamics and Electron Construction

The Static law of gravity means that mass M at distance r creates the static gravitational field:

$$G=\frac{\gamma M}{r^2}.$$

Taking into account that the gravitational constant γ has mechanical dimensionality $m^3/kg{\cdot}s^2$, one obtains that gravitational field has dimensionality of acceleration m/s^2.

The Electric charge at distance r creates static Coulomb field:

$$E=\frac{q}{4\pi\varepsilon_0 r^2}.$$

But we can say nothing about the mechanical dimensionality of E until the mechanical dimensionality of electric charge q is defined. If we could do this, we would obtain a clear formal relationship with mechanics, and between gravity and electricity.

In §6 it is shown that the electric charge has dimensionality kg/s, and the electric field has dimensionality of velocity, *i.e.,* m/s. The electric constant ε_0 has dimensionality of mass density, *i.e.,* kg/m^3. Its physical meaning is mass density of free ether. The aim of this Appendix is to extend these results on electrodynamic and gravidynamic fields. It was proposed to describe the gravity field with the help of Maxwell type equations in which the first time derivatives are changed for the second time derivatives. This means, in particular, that gravitation is understood as a field of accelerations, in contrast to electricity, which is a field of velocities. Respectively, these fields are characterized with constants that have the dimensionality of acceleration for gravity and the dimensionality of velocity (light speed c) for electricity.

Gravity preserves its one natural mechanical dimensionality. It has dimensionality of acceleration, and its charge is mass. But several dimensionality systems are used in electrodynamics. To my knowledge, scientists who use a certain system are its devoted supporters, and do not see any problems with its usage.

All can agree on the following point. Really, physics in general, and electricity in particular, may be studied in any language: in English, Chinese, or even Russian. But for every individual, there is among all of them a unique, preferred language. In this language, our intuition works better, we understand the interdependence of different phenomena better, we better express our ideas better, and we understand other persons better. This is our native language.

Do physicists have such a language? I am sure they have. This language is language of mechanics. Therefore, the method of gravity description mentioned above should be considered natural and understandable, and all dimensionality systems used in modern electrodynamics should be recognized as artificial and inconvenient. If the electric field has dimensionality of velocity, then all electrodynamic values obtain mechanical dimensionalities. In particular, electric charge has dimensionality kg/s, *i.e.,* mass time derivative.

In different times, different authors have come to this conclusion, although starting from different concepts. Papers by Aszukovsky [23] and Prussov [24] must be mentioned in this connection. But it is not enough for us to know dimensionalities of the described objects. We must translate electrodynamic values used in present-day terms into terms of mechanics.

That is what V.A. Aszukovsky writes in discussing this problem in his paper [23] (p. 49). He comes to conclusion that the electric constant ε_0 means mass density ρ of ether, and that dimensionality "Farad" corresponds mechanical dimensionality kg/m^2. He concludes from here that ether mass density must be equal to 8.85×10^{-12} kg/m^3 because $\varepsilon_0 = 8.85\times10^{-12}$ F/m. But this conclusion is wrong because it rests on a logical flaw. The fact that capacitance is measured in Farad and kg/m^2 does not mean that 1 F = 1 kg/m^2. And just such a correlation between units we must find in order to transform one dimensionality into another one. One easily sees that the assertion that mass may be measured in grams and kilograms does not mean that 1 g = 1 kg. Therefore, other quantitative evaluations in Aszukovsky book [23] seem to be unnatural.

It is known that the ration of the electric repulsion and gravitational attraction of two electrons is

$$\frac{F_e}{F_g}=\frac{q^2}{4\pi\gamma\varepsilon_0 m^2}=4.1659\times10^{42}. \tag{3.2.1}$$

In order to use this equality, we must adopt a certain model of elementary particles in general and of the electron in particular. Some authors (in addition to above-mentioned Aszukovsky and Prussov, F.M. Kanarev [26] should be mentioned) proposed models of elementary particles as follows: ether particles form a

torus performing two curling movements: in equatorial and meridional planes. The Similarity between models of this author and the above-mentioned authors stop here, as these rotations are prescribed different physical meanings. The present author believes that the equatorial rotation determines electric charge, and the meridional rotation determines the spin of the particle.

The electron's charge is:

$$q = m_e \omega, \tag{3.2.2}$$

where m_e is its mass and ω is the equatorial rotation angular velocity. It avers that electric current

$$J_e = qV = m_e \omega_e V \tag{3.2.3}$$

has dimension kg·m/s, *i.e.*, is a special kind of gravicurrent. One can say that electric field is a special kind of gravifield.

Such a description of the charge is a natural consequence of the idea of translational movement in kinematics. As my reader may remember, the velocity of translational movement of a massive point is linked with rotation, and described there with the help of vector product of the radius vector and the angular velocity vector.

Substituting (3.2.2) into (3.2.1) one obtains:

$$\frac{\omega^2}{4\pi\gamma\varepsilon_0} = 4.1659 \times 10^{42}. \tag{3.2.4}$$

We are compelled now to adopt some suppositions linking the gravitational constant γ and electric constant ε_0. In our next papers we show that the electric field is a special case of the gravitational one. This means that ε_0 and $1/\gamma$ must be numerically equal (perhaps with the accuracy of 2π). The difference in dimensionalities is a consequence of the dimensionality difference between electric charge and mass. The difference in static gravitational and electric forces is determined by the angular velocity value ω in (3.2.4). $1/\gamma$ has dimension kg/m^{3}s^2, and the mechanical dimension of ε_0 is kg/m^3.

Assumption:

$$8\pi^2 \gamma \varepsilon_0 = 1 \ \frac{\text{rad}^2}{\text{s}^2}. \tag{3.2.5}$$

Angular velocity squared unit is in the right hand part here. In other words, we suppose that $1/4\pi\gamma$ and ε_0 are numerically equal with the accuracy of 2π.

Mass m_e crating electron performs vortical movement drawing torus. It is a topological product of two circumferences of r_e and $r_e/2$ radius. This rotational movement creates electric charge. Taking (3.2.5) and (3.2.4) into account, one obtains the angular ring rotation

$$\omega_e = 8.1426 \times 10^{20} \text{ rad/s}. \tag{3.2.6}$$

This number is close to the Compton electron angular velocity

$$\omega_C = \frac{c}{\lambda_C} = 7.7634 \times 10^{20} \ \frac{\text{rad}}{\text{s}}, \tag{3.2.7}$$

where λ_C is Compton wavelength of the electron. The radius of the greater electron's circle is

$$r_e = \frac{c}{\omega_C} = 3.8616 \times 10^{-13} \ \frac{\text{m}}{\text{rad}}, \tag{3.2.8}$$

i.e., Compton's electrons wave length. The rotation in meridional planes creates electron's spin. The radius of this vortex is

$$\rho_e = r_e/2 = 1.9308 \times 10^{-13} \ \frac{\text{m}}{\text{rad}}. \tag{3.2.9}$$

Its angular velocity is

$$\Omega_e = \frac{c}{\rho_e} = 1.5527 \times 10^{21} \text{ rad/s}. \tag{3.2.10}$$

The velocity of the greater and less circumferences are

$$C_e = r_e \omega_e = 3.1443 \times 10^8 \text{ m/s}, \tag{3.2.11}$$

$$c_e = \rho_e \Omega_e = 2.9979 \times 10^8 \text{ m/s}. \tag{3.2.12}$$

correspondingly.

Let us find numerical value of electron's spin (magnetic moment)

$$m_e \rho_e^2 \Omega_e = 5.2729 \times 10^{-35} \ \frac{\text{kg} \cdot \text{m}^2}{\text{s} \cdot \text{rad}} = \frac{\hbar}{2}. \tag{3.2.13}$$

It coincides with the experimental one.

Magnetic moment of the ring rotation (the smaller ring)

$$\mu_e = \frac{m_e \omega_e^2 r_e^2}{2} = \frac{m_e c^2}{2} \tag{3.2.14}$$

is just kinetic energy of the ring.

The moment of the ring impulse

$$L_e = m_e \omega_e r_e^2$$

is just gyromagnetic ratio

$$\frac{\mu_e}{L_e} = \frac{\omega_e}{2}.$$

One obtain for the meridional rotation of the ring

$$\begin{aligned} \mu_s &= \frac{m_e \Omega_e^2 r_e^2}{2} = \frac{m_e c^2}{2}, \\ L_s &= m_e \Omega_e \rho_e^2, \\ \frac{\mu_s}{L_s} &= \frac{\Omega_e}{2} = \omega_e. \end{aligned} \tag{3.2.15}$$

Gyromagnetic ratio for the ring is twice less than for the meridional vortex. And this is coordinated to experiment. Let us note that (3.2.14) and (3.2.15) are equal to Bohr's magneton. But in (3.2.15) μ_s must have two projections of different sign, because two vortexes of the opposite sign exist in any section of meridional rotation. The sum magnetic moment of electron (its kinetic energy) is

$$\mu = \mu_e + \mu_s = m_e c^2. \tag{3.2.16}$$

Electric charge of only one sign is defined in this section. The positive sign of proton will be find in Chapter 3.

Electron's mass is

$$m_e = 9.1094\times10^{-31}\ \text{kg}. \tag{3.2.17}$$

One obtains

$$q = 7.072\times10^{-10}\ \frac{\text{kg}\cdot\text{rad}}{\text{s}}. \tag{3.2.18}$$

One electron is 1.6022×10^{-19} of Coulomb. Therefore

$$1\ \text{C} = 4.414\times10^{9}\ \frac{\text{kg}\cdot\text{rad}}{\text{s}}. \tag{3.2.19}$$

Electric constant ε_0 in SI is

$$\varepsilon_0 = 8.8542\times10^{-12}\ \frac{\text{s}^4\text{A}^2}{\text{m}^3\text{kg}}. \tag{3.2.20}$$

One Ampere is numerically equal one Coulomb. Thus

$$\varepsilon_0 = 1.7251\times10^{8}\ \frac{\text{kg}\cdot\text{rad}^2}{\text{m}^3}. \tag{3.2.21}$$

Electric field has dimension m/s·rad, *i.e.*, it is velocity field.

One can find other values in tables 1 and 2.

Table 1. Electric values

Units of measurement	SI system	Mechanical system	Value
Electric current	A	kg·rad/s²	4.414×10^{9}
Electric charge	A·s = C	kg·rad/s	4.414×10^{9}
Electric potential, voltage, electromotive force	kg·m²/(A·s³) = V	m²/(s·rad)	2.227×10^{-10}
Electric field	kg·m/(A·s³) = V/m	m/(c·rad)	2.266×10^{-10}
Absolute permittivity	A²·s⁴/(kg·m³) = F/m	kg·rad²/m³	1.948×10^{19}
Electric dipole moment	A·s·m = C·m	kg·m·rad/s	4.414×10^{9}
Electric displacement field	A·s/m² = C/m²	kg·rad/(s·m²)	4.414×10^{9}
Polarity	A·s/m² = C/m²	kg·rad/(s·m²)	4.414×10^{9}
Capacitance	A²·s⁴/(kg·m²) = c/Ω = F	kg·rad²/m²	1.948×10^{19}
Current density	A/m²	kg·rad/(s²·m²)	4.414×10^{9}
Electrical resistance	kg·m²/(A²·s³) = V/A = Ω	m²·s/(kg·rad²)	5.133×10^{-20}
Electrical conductance	A²·s³/(kg·m²) = 1/Ω = Sm	kg·rad²/(m²·s)	1.948×10^{19}
Electrical resistivity	kg·m³/(A²·s³) = Ω·m	m³·s/(kg·rad²)	5.133×10^{-20}
Electrical conductivity	A²·s³/(kg·m²) = Sm/m	kg·rad²/(m³·s)	1.948×10^{19}
Apparent power	kg·m²/s³ = V·A = W	kg·m²/s³	0.99
Real power			
Reactive power	kg·m²/s³ = var	kg·m²/s³	0.99

Table 2. Magnetic values

Units of measurement	SI system	Mechanical system	Value
Magnetic flux	kg·m²/(A·s²) = V·s = Wb	m²/rad	2.266×10^{-10}
Magnetic field strength	kg/(A·s²) = V·s/m² = T	1/rad	2.266×10^{-10}
Absolute permeability	kg·m/(A²·s²) = H/m	m·s²/(kg·rad²)	5.133×10^{-20}
Magnetic moment	A·m²	kg·m²·rad/s²	4.414×10^{9}
Magnetization	A/m	kg·rad/(m·s²)	4.414×10^{9}
Magnetic field	A/m	kg·rad/(m·s²)	4.414×10^{9}
Inductance	kg·m²/(A²·s²) = Ω·s = H	m²·s²/(kg·rad²)	5.133×10^{-20}
Magnetomotive force	A	kg·rad/s²	4.414×10^{9}
Magnetic reluctance	s²·A²/(m²·kg) = A/Wb	kg·rad²/(m²·s²)	1.948×10^{19}
Permeance	m²·kg/(s²·A²) = H	m²·s²/(kg·rad²)	5.133×10^{-20}
Magnetic vector potential	kg·m/(A·s²) = Wb/m	m/rad	2.266×10^{-10}

Radian is often omitted in papers. We consider it essential and as important as meters and seconds. Therefore we included it into all formulas manifestly.

3.3. The Magnetic Moment of the Electron

Electric field is a special case of gravidynamic field and magnetic field is manifestation of just gravidynamic field actually. In other terms if a certain particle displays possession of a magnetic field it does not mean yet that it is electrically charged. Magnetic moment of neutron corroborates this. For us here this means that when we try to describe magnetic moment of particles we must not link it with electric field but only with gravidynamic one.

In today physics defines the magnetic moment of a small current loop as pseudovector directed normally to the loop plane and modulo equal to:

$$M = IS, \tag{3.3.1}$$

where I is a current in the loop and S is the area. The mechanic dimension of (3.3.1) is kg·m²/s², because the ampere dimension is kg/s². Nowadays the magnetic moment of electron in the hydrogen atom is defined as pseudovector.

$$\tilde{\mathbf{M}}_\text{e} = \frac{\mu_0}{2} e(\mathbf{u}\times\mathbf{r}), \tag{3.3.2}$$

where μ_0 is the magnetic constant, e is electron charge, $\mathbf{u}$ is its velocity on Bohr orbit, $\mathbf{r}$ is a radius-vector. If we put:

$$u\cdot r = \frac{\hbar}{m_e} \tag{3.3.3}$$

then:

$$\tilde{M}_\text{e} = \frac{\mu_0}{2}\frac{e}{m_e}\hbar = 1.15\times10^{-29}\ \text{V}\cdot\text{m}\cdot\text{s}. \tag{3.3.4}$$

Taking Table 1 into account, one obtains:

$$\tilde{M}_\text{e} = 2.6402\times10^{-39}\ \text{m}^3. \tag{3.3.5}$$

A difference in dimensionalities from (3.3.1) appears because magnetic constant μ_0 was introduced into definition (3.3.2). One obtains dividing by μ_0:

$$\bar{M}_\text{e} = \frac{e}{2m_e}\hbar = 4.0936\times10^{-14}\ \frac{\text{kg}\cdot\text{m}^2\cdot\text{rad}^2}{\text{s}^2}. \tag{3.3.6}$$

This is Bohr magneton in mechanical dimensionalities. Experiment shows that electron magnetic moment is a little more actually:

$$M_e = 1.0011\,\bar{M}_e = 4.0981\times10^{-14}\ \frac{\mathrm{kg\cdot m^2\cdot rad^2}}{\mathrm{s^2}}. \qquad (3.3.7)$$

Let us consider a certain smaller circumference of torus and prescribe to it elementary mass dm such that integral over bigger circumference is equal to electron mass.

Assumption. Particles of this elementary massive circumference perform curling movement around tangent to this circumference with angular velocity ν_e.

Thus electron surface turns to consist of elementary vortexes, which may be imagined as a wire winded on torus. In other words we liken electron to toroidal solenoid. Nevertheless it is necessary to mention that there is no electric current here in macroscopic sense. Today current is understood as electrons movement. But just electron we try to describe now. Magnetic effect is also not linked with equatorial rotation of the torus, which defines electric charge.

Definition. Magnetic moment of electron is a pseudovector directed normally to lesser torus circumference and modulo equal to product of ν_e^2 and torus lesser circle square and electron mass.

$$M_e = m_e \pi \rho_e^2 \nu_e^2. \qquad (3.3.8)$$

Here we actually reproduce definition (3.3.1). Expression $m_e\nu_e^2$ is an accurate analogue of macroscopic current in toroidal induction coil. One obtains using (3.3.7) and (3.3.8):

$$\nu_e = \pm 6.1978\times10^{20}\ \frac{\mathrm{rad}}{\mathrm{s}}. \qquad (3.3.9)$$

We assume that positive ν_e corresponds to parallel direction of $\mathbf{M}_e$ and spin and negative ν_e to their antiparallel direction. Comparing definitions (3.3.4) and (3.3.6) we begin to understand why electron magnetic moment is not equal to Bohr magneton accurately. Definition (3.3.4) includes compressibility of free ether μ_0 but in the body of electron it is apparently bigger:

$$\mu = 1.0011\mu_0 = 6.4569\times10^{-26}\ \frac{\mathrm{m\cdot s^2}}{\mathrm{kg\cdot rad}}. \qquad (3.3.10)$$

Using numerical evaluation (3.3.9) we are able to find local light velocity in electron body:

$$c_m = \rho_e\nu_e = 1.1967\times10^{8}\ \frac{\mathrm{m}}{\mathrm{s}}. \qquad (3.3.11)$$

Rotation velocity of the lesser circumference:

$$c_e = \rho_e\Omega_e = 2.9979\times10^{8}\ \frac{\mathrm{m}}{\mathrm{s}}, \qquad (3.3.12)$$

$$\frac{c_e}{c_m} = 2.5. \qquad (3.3.13)$$

From here ether mass density in torus body:

$$\varepsilon = \frac{1}{c_m^2\mu} = 1.0815\times10^{9}\ \frac{\mathrm{kg}}{\mathrm{m^3}}. \qquad (3.3.14)$$

We are here on the verge of round off mistakes.

Some words follow on the gyromagnetic ratio.

$$\frac{2M_e}{\hbar} = 7.772\times10^{20}\ \frac{\mathrm{rad}}{\mathrm{s}} = \omega_e, \qquad (3.3.15)$$

This just shows that electron charge to its mass ratio is equal to ω_e.

3.4. Plank's Constant

Dimension "radian" appears in all the formulas (3.2.18)–(3.2.21). It shows that a rotational process is described by them.

Not enough attention is paid to rotation movement in modern physics. This ignorance is motivated in particular in lighting habit not to mention dimension "radian" in formulas. One cannot agree with such situation. Supposition that all physical values in mechanics can be described with the help of three main values: kg (mass), m (length) and s (time) is based on ancient metaphysical principle that any essence can be described with three variables. But nowadays "rotation angle" has actually entered into mechanics as the fourth main variable. Its absence in formulas where it is necessary essentially hampers their understanding. Therefore "radian" will appear everywhere where it is necessary.

Some problems appear on this way. Let us consider some of them. In modern physical papers two constants both called Planck's ones are used as equal in rights:

$$\hbar = 1.0544\times10^{-34}\,\frac{\mathrm{kg\cdot m^2}}{\mathrm{s}} \qquad (3.4.1)$$

and

$$h = 6.5626\times10^{-34}\,\frac{\mathrm{kg\cdot m^2}}{\mathrm{s}} = 2\pi\hbar. \qquad (3.4.2)$$

But numerously different values can describe the same physical value only if they depend on one parameter in addition and this parameter compensates their digital difference. Such parameter for (3.4.1) and (3.4.2) naturally becomes "angle" and units with which this angle is measured. h and $\hbar$ describe the same physical value only if

$$h = 6.5626\times10^{-34}\,\frac{\mathrm{kg\cdot m^2}}{\mathrm{s\cdot rev}} = \frac{6.5626}{2\pi}\times10^{-34}\,\frac{\mathrm{kg\cdot m^2}}{\mathrm{s\cdot rad}} =$$
$$= 1.0544\times10^{-34}\,\frac{\mathrm{kg\cdot m^2}}{\mathrm{s\cdot rad}} = \hbar.$$

General Assembly on Measures and Weights (1960) classified SI unit "radian" intentionally not answering the question: did it consider plain angle as main or as a derivative value. Here and in other our papers these authors consider angle as the main value – vector in threedimensional space of plain coordinates.

Considering angle as the forth main value in mechanics compels us to more accurately consider the used mathematical apparatus.

One example. How should we understand strictly harmonic oscillations:

$$x = A\sin\omega t, \tag{3.4.3}$$

where A is an amplitude, ω is an angle velocity, t is a time, x is a coordinate? Eq. (3.4.3) is often understand as identity. Identity can be differentiated. One obtains having differentiated (3.4.3): wave movement velocity

$$\frac{dx}{dt} \equiv v = A\omega\cos\omega t. \tag{3.4.4}$$

Taking into account angle as a main value we can immediately see our mistake: the dimension of the left hand part in (3.4.4) is [m/s]. The dimension of the right hand part is [m·rad/s]. We have equaled two values of different dimensions. Conclusion: (3.4.3) is an equation. We have no right to differentiate equation.

Interaction of different values in physics also compels us to more accurately put problems.

Electron's Compton wave length is defined as

$$\begin{aligned} \lambda = \hbar/\omega_e c = 3.8615\times10^{-13}\ \text{m/rad}= \\ = 2\pi\cdot 3.8615\times10^{-13}\ \text{m/rev.} \end{aligned} \tag{3.4.5}$$

Dimension "radian" appears here because $\hbar$ depends on angle. Is this correct? Yes, it is. When we describe radian and oscillation we must take into account that wave length is an angle function. Therefore for instance definition of "wave number":

$$k = \frac{d\varphi}{dr}\left[\frac{\text{rad}}{\text{m}}\right] \tag{3.4.6}$$

is correct.

When we describe rotational movement as a product of angular velocity and radius:

$$\mathbf{v} = \boldsymbol{\omega}\times\mathbf{r}, \tag{3.4.7}$$

we must take into account that $\boldsymbol{\omega}$ has dimension [rad/s]. If $\mathbf{r}$ just a length, expressed in meters we obtain tangential velocity $\mathbf{v}$ [m·rad/s]. If we want to describe movement of a load on needle winding around a pencil, we must start not from equity (3.4.7) but from equity

$$\frac{d}{dt}(r\varphi) = \dot{r}\varphi + \dot{\varphi}r \equiv v\varphi + \omega r, \tag{3.4.8}$$

Here φ is angle, $\dot{r}$ and $\dot{\varphi}$ are time derivatives. In (3.4.8) we consider one dimensional (plain) rotation. In general when $\mathbf{r}$ and $\boldsymbol{\varphi}$ are vectors it is necessary to use formulas for vector product [§12, IV]. But here we are interested only in the problem of dimensional. In the case of a load on a needle we should consider the second time derivative because the load is accelerated:

$$\frac{d^2}{dt^2}(r\varphi) = \ddot{r}\varphi + 2\dot{r}\dot{\varphi} + r\ddot{\varphi} \equiv d\varphi + 2v\omega + r\varepsilon, \tag{3.4.9}$$

where v and a are space velocity and acceleration and ω and ε are angular velocity and acceleration. The dimension of items in (3.4.8) is [m·rad/s] and in (3.4.9) is [m·rad/s²]. We deviated contradiction because we started with identities and not equations.

We are compelled to formulate problem in other way if we want, for instance, to find velocity or acceleration of the wave created by electron. Electron's Compton wave length has dimension [m/rad]. For this problem we have:

$$\frac{d}{dt}(\lambda\varphi) = \frac{\partial\lambda}{\partial\varphi}\cdot\dot{\varphi}\cdot\varphi + \lambda\dot{\varphi} \equiv \omega\left(\frac{\partial\lambda}{\partial\varphi}\varphi + \lambda\right) \tag{3.4.10}$$

instead of (3.4.8). All items here have dimension [m/s], *i.e.* (3.4.10) defines space (linear) wave velocity and not tangential one as in (3.4.7). If we calculate the second derivative we obtain dimension [m/s²], *i.e.* space acceleration of the wave.

But let us return to (3.2.21). Dimension of ε_0 shows that a certain medium exists between two charges in Coulomb formula. And this medium influences on the value of the force between charges. Someone calls this medium ether someone – physical vacuum. We shall use term ether having mentioned preliminary that "our ether" not inevitably coincides with the ideas of XIXth century scientists although do not exclude some coincides with Maxwell's ether for instance. Evaluation (3.2.21) shows that ether is a very dense medium. Sometimes they say that such density hinders for the planets to move in space. Let us remind that not medium's density but its viscosity hinders our movement and not Newtonian dynamic which is universe density. Thus big value (3.2.21) is a witness for the defense for the free movement in space.

But can we come from qualitative evaluations to quantitative ones? Yes, we can. The value we need was under cover of "nick" impedance. Impedance has dimension of viscosity per one ampere. Mechanic value of impedance is

$$I = \frac{1}{c\varepsilon_0} = 1.9336\times10^{-17}\ \frac{\text{m}^2\cdot\text{s}}{\text{kg}\cdot\text{rad}^2}. \tag{3.4.11}$$

If we multiply it by 1 Ampere we obtain:

$$\begin{aligned} \nu = I\cdot 4.414\times10^{9}\ \frac{\text{kg}\cdot\text{rad}}{\text{s}^2} = \\ = 8.5349\times10^{-8}\ \frac{\text{m}^2}{\text{s}\cdot\text{rad}} = 376.73\ \Omega. \end{aligned} \tag{3.4.12}$$

Eqs. (3.4.11) and (3.4.12) are apparently just another version of the Hubble's constant. If we multiply (3.4.12) by the ether's density (3.2.21) we obtain

$$\eta = \nu\varepsilon_0 = 14.7235\ \frac{\text{kg}\cdot\text{rad}}{\text{m}\cdot\text{s}}. \tag{3.4.13}$$

High density (3.2.21) is qualitative in agreement with one ether's quality in addition: light wave has normal component. In the media habitual to us we observe normal component only in the waves in rigid bodies.

Big value of light velocity means that ether must be very elastic or this is the same almost not contracted. Magnetic constant gives us the quantitative value of the ether's compressibility

$$\mu_0 = 6.4498\times10^{-26}\ \frac{\text{m}\cdot\text{s}^2}{\text{kg}\cdot\text{rad}^2}. \tag{3.4.14}$$

Thus we again obtain evaluations our a priori demands for ether.

4. Wave Solution of Generalized Maxwell Equations and Quantum Mechanics

4.1. Gravitational Model of the Electron

Let $\mathbf{R}$ be the radius vector from the greater circumference to its points, and $\boldsymbol{\rho}$ be the radius vector from the center of the lesser circumference to points such that it extends vector $\mathbf{R}$. And let pseudo-vectors $\boldsymbol{\omega}$ and vector $\boldsymbol{\Omega}$ be angular velocities of these circumferences. Let us introduce the main characteristics of electron:

The angular momentum

$$\mathbf{S}=\mathbf{R}\times(\boldsymbol{\omega}\times\boldsymbol{\rho})=\boldsymbol{\omega}\cdot(\mathbf{R}\cdot\boldsymbol{\rho})=\tfrac{1}{2}\boldsymbol{\omega}\cdot R^2=\tfrac{1}{2}\boldsymbol{\hbar}, \tag{4.1.1}$$

$$|\mathbf{S}|=0.527\times10^{-34}\ \text{kg}\cdot\text{m}^2/\text{s}. \tag{4.1.2}$$

Let us note that P.M. Kanarev was apparently the first person who raised a problem of vector interpretation of Planck's constant [27].

The vector $\boldsymbol{\hbar}$ in (4.1.1) is directed along the angular velocity $\boldsymbol{\Omega}$ of the torus lesser circumference rotation, and is proportional to it. It will be shown below that $\boldsymbol{\omega}$ is always directed parallel or anti-parallel to the electron's velocity and perpendicular to $\boldsymbol{\Omega}$. Therefore $\boldsymbol{\hbar}$ is modulo constant, and takes only two values: plus or minus. It depends on the screw that $\boldsymbol{\Omega}$ constitutes with electron velocity: it is left or right. This explains well-known problems of interpreting Planck's constant. The torus electric charge

$$\mathbf{e}=\pm m\frac{\boldsymbol{\omega}\times\boldsymbol{\Omega}}{|\boldsymbol{\Omega}|} \tag{4.1.3}$$

Plus or minus is taken depending on whether $\boldsymbol{\omega}$ constitutes a right or left screw with $\boldsymbol{\Omega}$. Let us note that $\boldsymbol{\Omega}$ is a polar vector.

The electric charge is polar vector modulo constant, and takes only two values: parallel or anti-parallel to radius $\mathbf{R}$. This characteristic is independent with respect to electron's movement and presents its inner quality. And this is in contrast to pseudo-vector $\boldsymbol{\hbar}$, which is defined only with respect to electron's velocity. It is problem for future experiments to define which sign in (4.1.3) corresponds to the electron. We assume sign plus. Sometimes we shall not mention radian following not the best tradition and considering magnetic field as nondimesional one. The electromagnetic field in general turns out to be a special case of gravity.

Let us calculate the electron's kinetic energy. The kinetic energy of its equatorial rotation is

$$K_1=\tfrac{1}{2}mR^2\omega^2=\tfrac{1}{2}mc^2.$$

The kinetic energy of its meridional rotation is

$$K_2=\tfrac{1}{2}m\rho^2\Omega^2=\tfrac{1}{2}mc^2.$$

The sum kinetic energy is

$$K=K_1+K_2=mc^2.$$

We find the same result in another way:

$$\boldsymbol{\hbar}\cdot\boldsymbol{\omega}=mc^2. \tag{4.1.4}$$

Let us introduce some additional notions that will be necessary in later Sections. It was noted above that $|\mathbf{R}|$ coincides with the Compton wavelength of the electron. Let

$$\mathbf{R}=(R_1,R_2,R_3). \tag{4.1.5}$$

If the wave created by the electron were monochromatic, we should introduce the wave vector parallel to electron's velocity $\mathbf{v}$. The vortical character of electron forces makes us introduce a normal vector

$$\mathbf{p}=\left(\frac{2\pi}{R_1},\frac{2\pi}{R_2},\frac{2\pi}{R_3}\right),\ |\mathbf{p}|=\frac{2\pi}{|\mathbf{R}|},\ \mathbf{p}||\mathbf{R}. \tag{4.1.6}$$

This is convenient because hydrodynamic considerations lead us to conclude that torus vortex of the above defined type must move along normal to its equatorial plane. We shall not prove this concept but just declare it, as:

Assumption 1. The velocity of an electron's movement is always perpendicular to its equatorial plane. Hence

$$\mathbf{p}\perp\mathbf{v}. \tag{4.1.7}$$

Assumption 2.

$$\mathbf{v}=\text{const}. \tag{4.1.8}$$

This assumption is very restrictive for electrons but rather natural for photons, which are perhaps the main objects of consideration here. Assumption 1 let us distinguish notions of charge and spin more accurately. They are both proportional to angular speed $\boldsymbol{\omega}$. But spin sign is not defined for a static electron. This means that spin is an external quality of electron.

Charge (4.1.3) is directed along radius $\mathbf{R}$ inside or outside; *i.e.*, along normal vector $\mathbf{p}$. It can also possess only two signs. But this is an inner characteristic of electron, a characteristic not dependent on its movement. Therefore, charge is adequately characterized with the help of scalar quantity: by vector modulus and its sign.

4.2. Wave Form of Generalized Maxwell Equations

Now we are to pass from the description of fields created by moving electrons to the description of waves created by such movement. In order to fulfill this task, we pass from real equations (2.2.2)–(2.2.5) to the following system of complex equations:

$$\nabla\cdot\mathbf{E}=i\omega\exp\{i(\mathbf{p}\cdot\mathbf{r})\}, \tag{4.2.1}$$

$$\nabla\times\mathbf{E}=-\frac{d\mathbf{B}}{dt}, \tag{4.2.2}$$

$$\nabla\cdot\mathbf{B}=-\frac{i\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r})\}, \tag{4.2.3}$$

$$c^2\nabla\times\mathbf{B}=\frac{d\mathbf{E}}{dt}. \tag{4.2.4}$$

Here i is the imaginary unit, ω is the angular speed of the electron torus; *i.e.,* the De-Broglie frequency of the electron at rest ($mc^2/\hbar$), $\mathbf{r}$ is the radius vector from the coordinate triple origin to the electron, $\mathbf{p}$ is the normal vector defined in the previous Section.

One can verify by direct substitution that the system (4.2.1)–(4.2.4) is satisfied by the functions

$$\mathbf{E} = \omega\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2c} - \frac{\mathbf{v}}{\omega}\right] + \frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}}{p^2}, \tag{4.2.5}$$

$$\mathbf{B} = -\frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2c} + \frac{\mathbf{v}}{\omega}\right] - \frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}}{p^2}. \tag{4.2.6}$$

Functions (4.2.5)–(4.2.6) define two waves: **1)** a traveling wave whose amplitude is the sum of two mutually perpendicular vectors, one is directed along velocity vector and the other one is perpendicular to it; and **2)** a standing wave whose oscillations are independent of time. The vector amplitude of this wave is directed perpendicular to the plane defined by traveling wave amplitude.

Let us verify by direct substitution that functions (4.2.5) and (4.2.6) are really solutions of (4.2.1)–(4.2.4) system. For (4.2.1),

$$\nabla\cdot\mathbf{E} = i\omega\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2c} - \frac{\mathbf{v}}{\omega}\right]\cdot\mathbf{p} + i\omega\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}\cdot\mathbf{p}}{p^2} = i\omega\exp\{i(\mathbf{p}\cdot\mathbf{r})\}. \tag{4.2.7}$$

The first item here is null because $\mathbf{p}$ is perpendicular to both vectors in brackets. Equality (4.2.3) is verified in the same way. Let us verify the (4.2.2) equality:

$$\nabla\times\mathbf{E} = i\omega\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\,\mathbf{p}\times\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2c} - \frac{\mathbf{v}}{\omega}\right] + i\omega\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}\times\mathbf{p}}{p^2}. \tag{4.2.8}$$

$$-\frac{d\mathbf{B}}{dt} = \frac{\omega}{c}(\mathbf{v}\cdot\nabla)\left\{\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2c} - \frac{\mathbf{v}}{\omega}\right] + \frac{\omega}{\mathrm{c}}\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}}{p^2}\right\} - \frac{i\omega^2}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2c} + \frac{\mathbf{v}}{\omega}\right]. \tag{4.2.9}$$

The first item here is a convective derivative of $\mathbf{B}$. It is null because

$$\nabla\left(\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\right) = i\mathbf{p}\left(\exp\{i(\mathbf{p}\cdot\mathbf{r} - \omega t)\}\right).$$

and vector $\mathbf{p}$ is perpendicular to $\mathbf{v}$. This means that when t is fixed, the wave moves along level curves $\mathbf{E}(x_1, x_2, x_3, t) = \text{const}$ and $\mathbf{B}(x_1, x_2, x_3, t) = \text{const}$. The condition $\mathbf{p}\cdot\mathbf{r} = \text{const}$ defines a surface for any t. In our case, this is just a plane. Let us note that the trajectory lies in this plane, in contrast to the planar wave trajectory, which is perpendicular to such a plane. The only nonzero item in (4.2.9) is the second one, which is partial derivative of $\mathbf{B}$ with respect to time. One gets equality to (4.2.8) if multiplier ω/c multiplies vector amplitude in the square brackets because $\omega/p^2c^2 = 1/\omega$. Equality (4.2.4) is verified in the same way.

Longitudinal and transverse oscillations take place in the traveling wave defined by the first items in (4.2.5) and (4.2.6). This wave is null if electron is in rest ($\mathbf{v} = 0$). The standing wave defined by the second items in (4.2.5) and (4.2.6) depends only on spatial coordinates. It does not move with any velocity in space, but exists eternally. Just this item originates the Coulomb interaction. Therefore one can say that the Coulomb force is a long-range one, in contrast to interactions connected with charges' movement, which spread with light velocity. Waves (4.2.5) and (4.2.6) as a whole are essentially three-dimensional, and cannot be described by plane monochromatic wave.

We have verified that functions (4.2.5)–(4.2.6) yields eq. (4.2.1)–(4.2.2). The eq. (4.2.3)–(4.2.4) are verified in the same way.

4.3. The Photon

The fundamental distinction between the photon and the electron is the lack of electric charge in the photon. Let us consider experiments on electron-positron annihilation in order to imagine the photon visually. It was assumed above that electrons and positrons differ in their meridional rotation with respect to their equatorial one. They both move along normal to their equatorial planes. Contacts of the following kinds are possible for them:

1. Their equatorial rotation directions coincide, *i.e.,* their spins are anti-directed. When they turn to be in contact, tori must be broken because of the opposite direction of their meridional rotations. The number of new cylinders (particles) created in such collisions increase with increasing collision energy.

2. Electron and positron equatorial rotation directions are opposite. Tori are torn because of oppositely directed equatorial rotations at the contact point. Two cylinders rotating around their axes are created.

Instead of (4.1.1), one gets for photon spin

$$\mathbf{S} = \mathbf{R}\times(\boldsymbol{\omega}\times\mathbf{R}) = \boldsymbol{\omega}\mathbf{R}^2 = \boldsymbol{\hbar}.$$

So we are compelled to accept as a photon model a cylinder rotating around its axis and oscillating along it. Let us stress that this model is no more than a visual image, which just provides a certain "visual hook" for the reader. The formal mathematical apparatus, the description of which we are passing to, works independent of this image; for instance, if the photon is a torus without equatorial rotation. In this case, longitudinal oscillation

takes the meaning of the lesser torus radial oscillation. I believe that an adequate model may be constructed only in terms of complex functions, or even quaternions.

Let us describe the photon's content mathematically. It does not possess electric charge. Therefore its initial conditions (divergence equalities) should be null. We have

$$\nabla\cdot\mathbf{E}=0, \tag{4.3.1}$$

$$\nabla\times\mathbf{E}=-\frac{d\mathbf{B}}{dt}, \tag{4.3.2}$$

$$\nabla\cdot\mathbf{B}=0, \tag{4.3.3}$$

$$c^2\nabla\times\mathbf{B}=\frac{d\mathbf{E}}{dt}. \tag{4.3.4}$$

As was done in the previous Section, we can use direct substitution to verify that solutions for this system are provided by the functions

$$\mathbf{E}=\omega\exp\{i(\mathbf{p}\cdot\mathbf{r}-\omega t)\}\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c}-\frac{\mathbf{c}}{\omega}\right], \tag{4.3.5}$$

$$\mathbf{B}=-\frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r}-\omega t)\}\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c}+\frac{\mathbf{c}}{\omega}\right]. \tag{4.3.6}$$

Bold $\mathbf{c}$ here means photon's vector speed. Only the traveling wave is preserved in (4.3.5)–(4.3.6), in contrast with the electron wave. The waves define torsion oscillations in the plane perpendicular velocity and longitudinal oscillations along it, just as in (4.2.5) and (4.2.6) waves. One can imagine it visually as cylinder-photon rotation around its axis and longitudinal oscillations along it. The cylinder axis is directed along velocity.

Certainly photons are originated not only in the process of charge annihilation. The necessary and sufficient conditions for photon origination should be found in the future. In general one can assert that photons are ether vortexes, which appear from many different causes. Therefore, different masses from ether are drawn into vortexes, and photons are created possessing different sizes and frequencies. Let us try to understand how these parameters should look in order to satisfy well-known experimental facts. Photon is not electrically charged, *i.e.,* only angular velocity of cylinder rotation is left for photon. Just this rotation originals spin. First of all, the following equality should hold

$$\frac{m}{p^2}\boldsymbol{\omega}=\boldsymbol{\hbar}. \tag{4.3.7}$$

Here m is photon mass drawn into the vortex when it was created in ether, $\mathbf{p}$ is normal vector directed from cylinder axis perpendicular velocity, $\boldsymbol{\omega}$ is angular velocity (frequency), $\boldsymbol{\hbar}$ is vector Planck constant. We accept equality (4.3.7) as non-deductive fact justified by experiments.

When (4.3.7) is scalar-multiplied by $\boldsymbol{\omega}$ one gets.

$$\frac{m\omega^2}{p^2}=mc^2=\boldsymbol{\hbar}\cdot\boldsymbol{\omega}. \tag{4.3.8}$$

We can come to this result starting from (4.3.5) and (4.3.6) fields. Let us find work produced by these fields. This work defines photon energy (4.3.8) got from (4.3.7).

Let $\mathbf{E}^*$ be function complex conjugate to $\mathbf{E}$. Then

$$\mathbf{E}\mathbf{E}^*=\omega^2\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c}-\frac{\mathbf{c}}{\omega}\right]^2=2c^2. \tag{4.3.9}$$

The kinetic energy of the electric field is

$$K=\frac{1}{2}m\mathbf{E}\mathbf{E}^*=mc^2. \tag{4.3.10}$$

Magnetic field energy should be summed with K. Or, to be accurate, energy originated by magnetic field projection on $\mathbf{E}$ should be added to (4.3.10) because force perpendicular to $\mathbf{E}$ does not produce work.

Eqs. (4.3.5) and (4.3.6) look as if they are collinear. Let us verify this supposition. The scalar production of vector amplitudes in (4.3.5) and (4.3.6) is

$$\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c}+\frac{\mathbf{c}}{\omega}\right]\cdot\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c}-\frac{\mathbf{c}}{\omega}\right]=\left[\frac{(\mathbf{p}\times\mathbf{c})^2}{p^4c^2}-\frac{c^2}{\omega^2}\right]=\left[\frac{1}{p^2}-\frac{1}{p^2}\right]=0,$$

i.e., $\mathbf{E}$ is perpendicular to $\mathbf{B}$, and the force created by $\mathbf{B}$ does not produce work and does not manifest itself in experiments. In other words, photon energy is defined by formula (4.3.10).

Certainly we could begin from magnetic field energy, computing

$$c^2\mathbf{B}\mathbf{B}^*=\omega^2\left[\frac{\mathbf{p}\times\mathbf{c}}{p^2c}-\frac{\mathbf{c}}{\omega}\right]^2=2c^2.$$

Here already electric field energy turns to be not revealed. Again we come to formula (4.3.10). If we take arbitrary direction and add vector electric and magnetic fields' projections on this direction, produce we come to the same result mc^2. Its physical meaning is also clear: the photon's kinetic energy is doubled because of its oscillations in two perpendicular dimensions. Let us compare it with electron's energy. One gets using (4.2.5) formula for electron's electric field:

$$\mathbf{E}\mathbf{E}^*=\omega^2\left[\frac{\mathbf{p}\times\mathbf{v}}{p^2c}-\frac{\mathbf{v}}{\omega}\right]^2+\frac{\omega^2}{p^2}=2v^2+c^2. \tag{4.3.11}$$

The kinetic energy of electron's electric field is

$$K=\frac{1}{2}m\mathbf{E}\mathbf{E}^*=mv^2+\frac{1}{2}mc^2. \tag{4.3.12}$$

But electron's electric and magnetic fields (4.2.5) and (4.2.6) contain a collinear part in addition: stable field directed along $\mathbf{p}$ which should be added to electric field energy. This magnetic field component is

$$\mathbf{B}=\frac{\omega}{c}\exp\{i(\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}}{p^2},$$

$$c^2\mathbf{B}\cdot\mathbf{B}^*=\frac{1}{2}mc^2.$$

Its kinetic energy is

$$K=\tfrac{1}{2}m\mathbf{B}\cdot\mathbf{B}^*=\tfrac{1}{2}mc^2. \tag{4.3.13}$$

When (4.3.13) and (4.3.12) are summed, one gets for the electron as a whole

$$K = mv^2 + mc^2. \tag{4.3.14}$$

We could begin, not with electric field, but with magnetic field, and we would come to the same result just as in the case of photon. The first item in (4.3.14) defines the electron motion contribution into its energy. It is originated by the electron's velocity. This result is in good accord with De-Broglie's concept about matter waves. Let us consider these approaches in greater details. De-Broglie's formula for the electron's energy is

$$K = mc^2 + \tfrac{1}{2} mv^2 + \ddot{I},$$

where $\ddot{I}$ is a potential energy, which is not defined explicitly. One can say that (4.3.14) defines potential energy in explicit form: it is equal to kinetic energy.

The second item in (4.3.14) is electron energy at rest. Numerically it is equal to energy of photon with electron mass. But their physical essence is different. In the case of electron this is energy of two fields oscillating in one dimension. Photon energy mc^2 corresponds to electron energy mv^2. Equality holds just because $v = c$ for the case. But photon possesses no energy of rest in contrast to electron.

The reader may feel certain dissatisfaction: why one field in traveling wave does not deposit into total energy. The answer is: imaginary part was essentially included into all our computations. We should not get accord with experiment if we took into account only real parts of fields. This means that imaginary part should be essentially included into fields' characteristics and nowadays it is completely ignored by physicists. One can call imaginary part of a field potential or nonrevealed one. In other terms (4.3.10) may be understood as kinetic and potential energy sum. Let us assert that potential energy notion is very vaguely defined in modern physics.

Although the derived results sometimes lead to new questions, nevertheless they solve some problems of modern physics, such as the electron's "electrodynamic mass", the electron's electric field energy infinity, the electron's self-action, *etc*. All these problems are solved because the electron is understood as rotation of a certain mass and the electric field is understood as a special case of gravity.

Let us consider one additional point. Photon "polarization" is defined most naturally in terms of the left or right screw that photon rotation forms with photon velocity. Linear polarization corresponds to oscillations in a fixed plane, along the $\mathbf{p}\times\mathbf{v}$ vector. A linearly polarized photon beam was used for experimental proof for alleged absence of longitudinal oscillations in photons: when an analyzer passing photons polarized in only one plane is turned through angle $\pi/2$, the light disappears. The reasoning is as follows. If photons would have longitudinal oscillations, the light should not disappear. But waves (4.3.5) and (4.3.6) are similar to waves on a boundary surface of two different media: longitudinal and transverse oscillations in such waves are connected. Suppression of oscillations of one type means immediate suppression of the other type of oscillations. The very idea that electromagnetic waves must be similar to boundary surface waves was proposed first by P.D. Prusov in his monograph [28].

Let us compare functions (4.3.5) and (4.3.6) with the waves traditionally considered in electrodynamics. The traditional form of Maxwell equations for light is

$$\nabla\cdot\mathbf{E} = 0, \tag{4.3.15}$$

$$\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}, \tag{4.3.16}$$

$$\nabla\cdot\mathbf{B} = 0, \tag{4.3.17}$$

$$c^2\nabla\times\mathbf{B} = \frac{\partial\mathbf{E}}{\partial t}. \tag{4.3.18}$$

The following functions are usually considered as solutions of this system

$$\mathbf{E} = \mathbf{E}_0 \exp\{i(\mathbf{k}\cdot\mathbf{r} - \omega t)\}, \tag{4.3.19}$$

$$\mathbf{B} = \mathbf{B}_0 \exp\{i(\mathbf{k}\cdot\mathbf{r} - \omega t)\}. \tag{4.3.20}$$

Let us recall that wave vector $\mathbf{k}$ is modulo equal to our normal vector $\mathbf{p}$, but is directed along the velocity vector, in contrast to $\mathbf{p}$ which is directed perpendicular to the velocity vector.

The convective derivatives of the functions in (4.3.5) and (4.3.6) are zero. Therefore these functions are also solutions not only for the (4.3.1)–(4.3.4) system, but also for the (4.3.15)–(4.3.18) system. Thus for a long time already, they could be considered as descriptions for electrodynamic waves. Apparently, the tradition for describing waves in habitual media made scientists consider only the functions (4.3.19) and (4.3.20) as solutions for the (4.3.15)–(4.3.18) system. But the plane wave description (4.3.19)–(4.3.20) does not take into account the torsion character of electromagnetic waves. Mathematically this is manifested in the fact that waves (4.3.19)– (4.3.20) do not satisfy generalized Maxwell equations (4.3.1)–(4.3.4). Plane waves describe electromagnetic waves only very inadequately. And this is manifested in well-known paradoxes of quantum mechanics.

4.4. Interaction Energy, Momentum, and Force for Two Photons

It was shown in §2 that energy and momentum of interaction should be found as a preliminary to calculate the interaction force for elementary particles. We begin with two photons. Let the electric and magnetic fields for photon 1 be represented by

$$\mathbf{E}_1 = \omega_1 \exp\{i((\mathbf{p}_1\cdot\mathbf{r}) - \omega_1 t)\}\left[\frac{\mathbf{p}_1\times\mathbf{c}_1}{p_1^2 c} - \frac{\mathbf{c}_1}{\omega_1}\right]. \tag{4.4.1}$$

$$\mathbf{B}_1 = -\frac{\omega_1}{c} \exp\{i((\mathbf{p}_1\cdot\mathbf{r}) - \omega_1 t)\}\left[\frac{\mathbf{p}_1\times\mathbf{c}_1}{p_1^2 c} + \frac{\mathbf{c}_1}{\omega_1}\right]. \tag{4.4.2}$$

Here $\mathbf{c}_1$ is the vector speed of photon 1, $|\mathbf{c}_1| = c$ the scalar light speed. Let the electric and magnetic fields the second photon be represented by

$$\mathbf{E}_2^* = \omega_2 \exp\{-i((\mathbf{p}_2\cdot\mathbf{r}) - \omega_2 t)\}\left[\frac{\mathbf{p}_2\times\mathbf{c}_2}{p_2^2 c} - \frac{\mathbf{c}_2}{\omega_2}\right], \tag{4.4.3}$$

$$\mathbf{B}_2^* = -\frac{\omega_2}{c} \exp\{-i((\mathbf{p}_2\cdot\mathbf{r}) - \omega_2 t)\}\left[\frac{\mathbf{p}_2\times\mathbf{c}_2}{p_2^2 c} + \frac{\mathbf{c}_2}{\omega_2}\right]. \tag{4.4.4}$$

where star denotes complex conjugate.

The interaction energy of the two photons is defined by formula (2.2.1), modified for two photons. Recall that the unique photon energy is constant, but the interaction energy oscillates and behaves like a wave. As a preliminary, let us calculate the following function defining energy oscillations:

$$K_{21}=c\mathbf{E}_1\cdot\mathbf{B}_2^*=-\omega_1\omega_2\exp\{i((\mathbf{p}_1-\mathbf{p}_2)\cdot \mathrm{r})-(\omega_1-\omega_2))t\}\cdot \\ \cdot\left[\frac{(\mathbf{p}_1\times\mathbf{c}_1)\cdot(\mathbf{p}_2\times\mathbf{c}_2)}{p_1^2p_2^2c^2}+\frac{\mathbf{c}_1(\mathbf{p}_2\times\mathbf{c}_2)}{\omega_1p_1^2c}-\frac{\mathbf{c}_2(\mathbf{p}_1\times\mathbf{c}_1)}{\omega_2p_2^2c}-\frac{\mathbf{c}_1\cdot\mathbf{c}_2}{\omega_1\omega_2}\right]. \tag{4.4.5}$$

The function

$$L_{12}=\frac{m_1\cdot m_2}{\varepsilon_0}K_{21} \tag{4.4.6}$$

is called "integral", or simply "interaction" energy if misunderstanding is impossible. It has dimension of energy multiplied by volume. Here m_1 and m_2 are the masses of the photons and ε_0 is the electric constant, the physical meaning of which is mass density of free ether. Photon 1 and photon 2 radius vectors $\mathbf{r}_1$ and $\mathbf{r}_2$ do not coincide, so certainly the exponent index in (4.4.5) should contain not $(\mathbf{p}_1-\mathbf{p}_2)\cdot\mathbf{r}$, but rather $(\mathbf{p}_1\cdot\mathbf{r}_1-\mathbf{p}_2\cdot\mathbf{r}_2)$. But here we speak about energy interaction in a certain interaction volume. Therefore one can define this volume by radius vector

$$\mathbf{r}=(\mathbf{r}_1+\mathbf{r}_2)/2. \tag{4.4.7}$$

Then

$$-\nabla L_{21}=-\frac{im_1m_2\omega_1\omega_2}{\varepsilon_0}\Delta\mathbf{p}\cdot\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\cdot \\ \cdot\left[\frac{(\mathbf{p}_1\times\mathbf{c}_1)\cdot(\mathbf{p}_2\times\mathbf{c}_2)}{p_1^2p_2^2c^2}+\frac{\mathbf{c}_1(\mathbf{p}_2\times\mathbf{c}_2)}{\omega_1p_1^2c}-\frac{\mathbf{c}_2(\mathbf{p}_1\times\mathbf{c}_1)}{\omega_2p_2^2c}-\frac{\mathbf{c}_1\cdot\mathbf{c}_2}{\omega_1\omega_2}\right]. \tag{4.4.8}$$

Here $\Delta\mathbf{p}=(\mathbf{p}_1-\mathbf{p}_2)$, $\Delta\omega=(\omega_1-\omega_2)$.

Eq. (4.4.8) has dimension of force multiplied by a volume, *i.e.*, force integrated with respect to volume. In a certain respect, this is symmetric to the concept of force density, which is force derivative with respect to volume. Eq. (4.4.8) will be called "integral" or simply "interaction" force. It describes the integrated action of photon 2 on photon 1 as an energy gradient.

Let us consider the physical meaning of functions (4.4.6) and (4.4.8) in some special cases. Let $\mathbf{c}_1=\mathbf{c}_2$; *i.e.*, let the photon velocities be co-directed, and let $|\omega_1|=|\omega_2|$. Also let $\omega=\pm|\omega_1|$. The case $\omega=+|\omega_1|$ corresponds the situation with co-directed spins and the case $\omega=-|\omega_1|$ corresponds the case of anti-directed spins. With $\omega=\omega_1$, the photons are coherent. If $\mathbf{c}_1=\mathbf{c}_2$, then vectors $\mathbf{p}_1$ and $\mathbf{p}_2$ are co-planar. But generally speaking, they are not collinear. The angle between them is defined by the photons' polarization difference. The $\Delta\mathbf{p}$ is analogous to phase remainder for transverse waves, and expresses polarization difference. If $\mathbf{p}_1=\mathbf{p}_2$, *i.e.*, in addition to the photon's coherency, their polarizations coincide. Then $\Delta\mathbf{p}=0$ and the whole force (4.4.8) is null. But the interaction energy (4.4.6) is not null. L_{21} does not oscillate because $\Delta\omega=(\omega_1-\omega_2)=0$, and (4.4.6) remains constant, and

$$L_{21}=\frac{m^2c^2}{\varepsilon_0}. \tag{4.4.9}$$

The equality $|\omega_1|=|\omega_2|$ yields $m_1=m_2=m$.

Let now $\mathbf{p}_1=-\mathbf{p}_2$, *i.e.*, let the photons be anti-polarized. Then $\Delta\mathbf{p}=2\mathbf{p}_1$. The spatial oscillation period is maximal, and

$$L_{21}=\frac{m^2c^2}{\varepsilon_0}\exp\{i(2\mathbf{p}_1\cdot\mathbf{r})\}, \tag{4.4.10}$$

$$\mathbf{F}_{21}^1=\frac{2im^2c^2}{\varepsilon_0}\exp\{i(2\mathbf{p}_1\cdot\mathbf{r})\}\mathbf{p}_1. \tag{4.4.11}$$

The interference picture is stable for the two cases considered. In general when general formulas (4.4.6) and (4.4.8) are valid, this picture becomes a function of space coordinates and time.

In modern physics, two force definitions are considered equivalent: force as momentum derivative with respect to time and force as energy gradient. Let us verify this assertion. Let $m\mathbf{v}$ be the momentum of a body and $\frac{1}{2}m\mathbf{v}^2$ its kinetic energy.

$$\frac{d}{dt}(m\mathbf{v})=m(\mathbf{v}\cdot\nabla)\mathbf{v}+\mathbf{v}(\mathbf{v}\cdot\nabla m)+\frac{\partial m}{\partial t}\mathbf{v}+m\frac{\partial\mathbf{v}}{\partial t}, \tag{4.4.12}$$

$$\nabla(\tfrac{1}{2}mv^2)=m(\mathbf{v}\cdot\nabla)\mathbf{v}+\tfrac{1}{2}v^2\nabla m. \tag{4.4.13}$$

Only the first item coincides in the right hand parts of these equalities. One can see that (4.4.12) and (4.4.13) coincide only if $m=\text{const}$ and $\mathbf{v}$ does not depend explicitly on time. Just this case is usually considered in textbooks. When interaction force is defined, this coincidence is also absent: the first item in (4.4.13) turns out to depend on the photons' velocities, and the first one in (4.4.12) depends on the photons' velocity vector difference.

Therefore the generalized Lorentz force (2.2.1) contains two items: interaction energy gradient and interaction momentum derivative. We have found the first item. Now let us find the second one. The interaction momentum in free ether is

$$\mathbf{P}_{21}=\frac{cm_1m_2}{\varepsilon_0}\left[\mathbf{B}_1\times\mathbf{B}_2^*\right]. \tag{4.4.14}$$

Substituting fields from (4.4.2) and (4.4.4), one gets:

$$\mathbf{P}_{21}=\frac{m_1m_2\omega_1\omega_2}{\varepsilon_0c}\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{c}_1)\times(\mathbf{p}_2\times\mathbf{c}_2)}{p_1^2p_2^2c^2}+\frac{\mathbf{c}_2\times(\mathbf{p}_1\times\mathbf{c}_1)}{p_1^2\omega_2c}+\frac{\mathbf{c}_1\times(\mathbf{p}_2\times\mathbf{c}_2)}{p_2^2\omega_1c}+\frac{\mathbf{c}_1\times\mathbf{c}_2}{\omega_1\omega_2}\right], \tag{4.4.15}$$

$$\frac{d}{dt}\mathbf{P}_{21}=(\Delta\mathbf{v}\cdot\nabla)\mathbf{P}_{21}+\frac{\partial\mathbf{P}_{21}}{\partial t}, \tag{4.4.16}$$

where $\Delta\mathbf{v}=\mathbf{v}_1-\mathbf{v}_2$. Taking into account (4.4.15), one gets:

$$\frac{d}{dt}\mathbf{P}_{21}\equiv\mathbf{F}_{21}^{2}=\frac{im_1m_2\omega_1\omega_2}{\varepsilon_0 c}(\Delta\mathbf{v}\cdot\Delta\mathbf{p}-\Delta\omega)\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\left[\frac{(\mathbf{p}_1\times\mathbf{c}_1)\times(\mathbf{p}_2\times\mathbf{c}_2)}{p_1^2p_2^2c^2}+\frac{\mathbf{c}_2\times(\mathbf{p}_1\times\mathbf{c}_1)}{p_1^2\omega_2 c}+\frac{\mathbf{c}_1\times(\mathbf{p}_2\times\mathbf{c}_2)}{p_2^2\omega_1 c}+\frac{\mathbf{c}_1\times\mathbf{c}_2}{\omega_1\omega_2}\right]. \quad (4.4.17)$$

$$\Delta\mathbf{v}\cdot\Delta\mathbf{p}=(\mathbf{v}_1-\mathbf{v}_2)\cdot(\mathbf{p}_1-\mathbf{p}_2)=\mathbf{v}_1\mathbf{p}_1-\mathbf{p}_1\mathbf{v}_2-\mathbf{p}_2\mathbf{v}_1+\mathbf{v}_2\mathbf{p}_2. \quad (4.4.18)$$

The extreme items here are null by definition. But generally speaking, the middle ones are not null. Hence

$$\Delta\mathbf{v}\Delta\mathbf{p}=-(\mathbf{p}_1\mathbf{v}_2+\mathbf{p}_2\mathbf{v}_1), \quad (4.4.19)$$

$$(\mathbf{p}_1\times\mathbf{c}_1)\times(\mathbf{p}_2\times\mathbf{c}_2)= \\ =\mathbf{p}_2(\mathbf{c}_2\cdot(\mathbf{p}_1\times\mathbf{c}_1))-\mathbf{c}_2(\mathbf{p}_2\cdot(\mathbf{p}_1\times\mathbf{c}_1)). \quad (4.4.20)$$

Let us consider some examples:

1. $\mathbf{c}_1 = \pm\mathbf{c}_2$.

The square brackets are null for this case. Hence momentum (4.4.15) and force (4.4.17) is null.

2. $\Delta\mathbf{p}\cdot\Delta\mathbf{v} - \Delta\omega = 0$.

The parentheses are null for this case and force (4.4.17) is null but momentum (4.4.15) is not null, it is stable.

In general (4.4.15) and (4.4.17) are not null and describe a certain wave or to be strict a certain torsional oscillation carrying mass or an oscillating vortex moving with light velocity in ether. The latter property attaches a particle quality to the photon. The following interaction force appears between two photons:

$$\mathbf{F}_{21}=\mathbf{F}_{21}^{1}+\mathbf{F}_{21}^{2}, \quad (4.4.21)$$

where items are defined by (4.4.8) and (4.4.17). If this force is null, then the two photons move "without hindering each other" (coherent photons with coinciding normal vectors $\mathbf{p}_1$ and $\mathbf{p}_2$ is the case). If the force (4.4.21) is not null, an interaction force directed to the velocity at a certain angle appears. $\mathbf{F}_{21}^{1}$ is directed along $\Delta\mathbf{p}$ and $\mathbf{F}_{21}^{2}$ is directed along vector in square brackets in (4.4.17). As a result a photons beam becomes cone shaped.

4.5. Interaction Energy, Momentum, and Force for Two Electrons

Let us consider the interaction of two electrons. The formulas we are going to consider are similar to the ones we got in the previous Section, but additional items appear because oscillations along normal vector $\mathbf{p}$ take place. Let $p_1^2=p_2^2=p^2$. Let the electric and magnetic fields of the first electron and the complex conjugate electric and magnetic fields of the second electron be:

$$\mathbf{E}_1=\omega_1\exp\{i(\mathbf{p}_1\cdot\mathbf{r}-\omega_1 t)\}\left[\frac{\mathbf{p}_1\times\mathbf{v}_1}{p^2c}+\frac{\mathbf{v}_1}{\omega_1}\right]+\omega_1\exp\{i(\mathbf{p}_1\cdot\mathbf{r})\}\frac{\mathbf{p}_1}{p^2}, \quad (4.5.1)$$

$$\mathbf{B}_1=-\frac{\omega_1}{c}\exp\{i(\mathbf{p}_1\cdot\mathbf{r}-\omega_1 t)\}\left[\frac{\mathbf{p}_1\times\mathbf{v}_1}{p^2c}+\frac{\mathbf{v}_1}{\omega_1}\right]+\frac{\omega_1}{c}\exp\{i(\mathbf{p}_1\cdot\mathbf{r})\}\frac{\mathbf{p}_1}{p^2} \quad (4.5.2)$$

$$\mathbf{E}_2^{*}=-\omega_2\exp\{-i(\mathbf{p}_2\cdot\mathbf{r}-\omega_2 t)\}\left[\frac{\mathbf{p}_2\times\mathbf{v}_2}{p^2c}+\frac{\mathbf{v}_2}{\omega_2}\right]+\omega_2\exp\{-i(\mathbf{p}_2\cdot\mathbf{r})\}\frac{\mathbf{p}_2}{p^2}, \quad (4.5.3)$$

$$\mathbf{B}_2^{*}=\frac{\omega_2}{c}\exp\{-i(\mathbf{p}_2\cdot\mathbf{r}-\omega_2 t)\}\left[\frac{\mathbf{p}_2\times\mathbf{v}_2}{p^2c}+\frac{\mathbf{v}_2}{\omega_2}\right]+\frac{\omega_2}{c}\exp\{-i(\mathbf{p}_2\cdot\mathbf{r})\}\frac{\mathbf{p}_2}{p^2} \quad (4.5.4)$$

The integral interaction energy for these two electrons is:

$$L_{21}=\frac{m_1m_2\omega_1\omega_2}{\varepsilon_0}\left\{\exp\{i((\mathbf{p}_1-\mathbf{p}_2)\cdot\mathbf{r}-(\omega_1-\omega_2)t)\}\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c^2}+\frac{\mathbf{v}_1\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{\omega_1p^2c}-\frac{\mathbf{v}_2\cdot(\mathbf{p}_1\times\mathbf{v}_1)}{\omega_2p_1^2c}-\frac{\mathbf{v}_1\cdot\mathbf{v}_2}{\omega_1\omega_2}\right]+\right. \\ +\exp\{i((\mathbf{p}_1-\mathbf{p}_2)\cdot\mathbf{r}-\omega_2 t)\}\cdot\left[\frac{\mathbf{p}_1\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c}-\frac{\mathbf{p}_1\cdot\mathbf{v}_2}{p^2c}\right]+\exp\{i((\mathbf{p}_1-\mathbf{p}_2)\cdot\mathbf{r}-\omega_1 t)\}\cdot\left[\frac{\mathbf{p}_2\cdot(\mathbf{p}_1\times\mathbf{v}_1)}{p^4c}-\frac{\mathbf{p}_2\cdot\mathbf{v}_1}{p^2c}\right]+ \\ \left.+\exp\{i((\mathbf{p}_1-\mathbf{p}_2)\cdot\mathbf{r})\}\cdot\frac{\mathbf{p}_1\cdot\mathbf{p}_2}{p^4}\right\}. \quad (4.5.5)$$

Let us explain (4.5.5) with the help of a rather a special but very important example. Let

$$\mathbf{v}_1=\mathbf{v}_2=0,\ \mathbf{p}_1=\mathbf{p}_2,\ \omega_1=\omega_2. \quad (4.5.6)$$

Conditions (4.5.6) mean that all the items in (4.5.5) are null except the last one, and the last item does not oscillate. One finds that the integral energy of two electrons at rest is

$$L_{21}=\frac{m_1\omega_1m_2\omega_2}{\varepsilon_0 p^2}. \quad (4.5.7)$$

The reader certainly remembers that $m_1\omega_1 = q_1$, $m_2\omega_2 = q_2$ are charges, the signs of which are defined by the signs of ω_1 and ω_2. Also $1/p^2 = R^2$, where R is radius of the greater circumference defining a torus and $\rho = R/2$ is the smaller circumference radius.

The condition $\mathbf{p}_1 = \mathbf{p}_2$ in (4.5.6) implies that the equatorial planes of the charges (tori) are parallel. Function (4.5.7) is the

integral energy acting in the volume between the equatorial section of the tori and the redoubled radius of the smaller circumference. Let us find it. The torus equatorial section square is

$$S = \pi\left[\left(\tfrac{3}{2}R\right)^2 - \left(\tfrac{1}{2}R\right)^2\right] = 2\pi R^2. \tag{4.5.8}$$

The interaction volume is

$$V = S\cdot R = 2\pi R^3. \tag{4.5.9}$$

Inside this volume, energy (4.5.7) is constant hence interaction force is null. We would like to understand how the charges interact at a distance $r > R$. The interaction energy for this case is

$$V = 2\pi R^2 \cdot r. \tag{4.5.10}$$

The formula for interaction energy also changes. It was shown above that in contact, interaction energy is redoubled. When remote charges are under consideration, we must use the classical formula for kinetic energy. In other words, we must divide integral energy (4.5.7) by volume (4.5.10) and by 2 in addition. One finally gets for this case that the usual, but not integral, energy is

$$E_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r}. \tag{4.5.11}$$

Calculating minus gradient of this energy, one finds that the already usual and not integral interaction force is

$$\mathbf{f}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}, \tag{4.5.12}$$

where $\mathbf{r}_{21}$ is radius- vector from charge 2 to charge 1. We have derived the usual Coulomb potential (4.5.11) and Coulomb force (4.5.12).

Let us weaken the first condition in (4.5.6), *i.e.*, let

$$\mathbf{v}_1 = \mathbf{v}_2 = \mathbf{v},\ \mathbf{p}_1 = \mathbf{p}_2,\ \omega_1 = \omega_2, \tag{4.5.13}$$

In other words, the charges move "side by side" with equal velocities. Taking into account that $\omega^2/p^2 = c^2$ one gets

$$E_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r}\left[1 - \frac{v^2}{c^2}\right], \tag{4.5.14}$$

$$\mathbf{f}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\left[1 - \frac{v^2}{c^2}\right]\mathbf{r}_{21}, \tag{4.5.15}$$

Eq. (4.5.15) is the traditional Lorentz force law. It weakens the Coulomb repulsion between two parallel beams of electrons, and displays an attractive force between two neutral conductors with parallel currents.

Let

$$\mathbf{v}_1 \cdot \mathbf{v}_2 = v^2 \cos\varphi \tag{4.5.16}$$

with $\cos\varphi = 1$ for parallel currents and $\cos\varphi = -1$ for anti-parallel currents. Therefore for

$$\mathbf{v}_1 = -\mathbf{v}_2,\ \mathbf{p}_1 = \mathbf{p}_2,\ \omega_1 = \omega_2, \tag{4.5.17}$$

the second item in square brackets changes its sign.

Let us find the gradient part of interaction force between two charges:

$$\begin{aligned} -\nabla L_{21} = -\frac{i m_1 m_2 \omega_1 \omega_2}{\varepsilon_0}\Delta \mathrm{p}\Big\{ &\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\}\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{p^4 c^2} + \frac{\mathbf{v}_1\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{\omega_1 p_1^2 c} - \frac{\mathbf{v}_2\cdot(\mathbf{p}_1\times\mathbf{v}_1)}{\omega_2 p_1^2 c} - \frac{\mathbf{v}_1\cdot\mathbf{v}_2}{\omega_1\omega_2}\right] + \\ &+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_1 t)\}\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\cdot\mathbf{p}_2}{p^4 c} - \frac{\mathbf{p}_2\cdot\mathbf{v}_1}{p^2 c}\right] + \exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_2 t)\}\cdot\left[\frac{\mathbf{p}_1\cdot(\mathbf{p}_2\times\mathrm{v}_2)}{p^4 c} - \frac{\mathbf{p}_1\cdot\mathbf{v}_2}{p^2 c}\right] + \exp\{i(\Delta\mathbf{p}\cdot\mathbf{r})\}\cdot\frac{\mathbf{p}_1\cdot\mathbf{p}_2}{p^4}\Big\}. \end{aligned} \tag{4.5.18}$$

This force depends on the electrons' absolute velocities with respect to ether. It was shown above that interaction force expressed as momentum total derivative with respect to time should be added to this force. Let us find it:

$$\begin{aligned} \mathbf{B}_1\times\mathbf{B}_2^* = -\frac{\omega_1\omega_2}{c^2}\Big\{ &\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \Delta\omega t)\}\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{p^4 c^2} - \frac{\mathbf{v}_2\times(\mathbf{p}_1\times\mathbf{v}_1)}{p_1^2 c\omega_2} - \frac{\mathbf{v}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^2 c\omega_1} + \frac{\mathbf{v}_1\times\mathbf{v}_2}{\omega_1\omega_2}\right] + \\ &+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_1 t)\}\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times\mathbf{p}_2}{p^4 c} - \frac{\mathbf{p}_2\times\mathbf{v}_1}{p^2\omega_1}\right] + \exp\{i(\Delta\mathbf{p}\cdot\mathbf{r} - \omega_2 t)\}\left[\frac{\mathbf{p}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4 c} - \frac{\mathbf{p}_1\times\mathbf{v}_2}{p^2\omega_2}\right] + \exp\{i(\Delta\mathbf{p}\cdot\mathbf{r})\}\frac{\mathbf{p}_1\cdot\mathbf{p}_2}{p^4}\Big\}. \end{aligned} \tag{4.5.19}$$

Let $\Delta\mathbf{v} = \mathbf{v}_1 - \mathbf{v}_2$ be electrons' velocities difference. Then

$$\frac{d}{dt}\left[\frac{m_1m_2c}{\varepsilon_0}\left(\mathbf{B}_1\times\mathbf{B}_2^*\right)\right]=-\frac{im_1m_2\omega_1\omega_2}{\varepsilon_0 c}(\Delta\mathbf{v}\cdot\Delta\mathbf{p})\cdot\left\{\exp\{\mathrm{i}(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c^2}+\frac{\mathbf{v}_2\times(\mathbf{p}_1\times\mathbf{v}_1)}{p_1^2c\omega_2}-\right.\right.$$
$$\left.-\frac{\mathbf{v}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^2c\omega_1}+\frac{\mathbf{v}_1\times\mathbf{v}_2}{\omega_1\omega_2}\right]+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\omega_1 t)\}\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times\mathbf{p}_2}{p^4c}+\frac{\mathbf{p}_2\times\mathbf{v}_1}{p^2\omega_1}\right]+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\omega_2 t)\}\cdot$$
$$\left.\cdot\left[\frac{\mathbf{p}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c}-\frac{\mathbf{p}_1\times\mathbf{v}_2}{p^2\omega_2}\right]+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r})\}\cdot\frac{\mathbf{p}_1\cdot\mathbf{p}_2}{p^4}\right\}-\frac{im_1m_2\omega_1\omega_2\Delta\omega}{\varepsilon_0 c}\left\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\cdot\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c^2}+\right.\right. \quad (4.5.20)$$
$$\left.\left.+\frac{\mathbf{v}_2\times(\mathbf{p}_1\times\mathbf{v}_1)}{p_1^2c\omega_2}-\frac{\mathbf{v}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^2c\omega_1}+\frac{\mathbf{v}_1\times\mathbf{v}_2}{\omega_1\omega_2}\right]\right\}-\frac{im_1m_2\omega_1\omega_2}{\varepsilon_0 c}\left\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\omega_1 t)\}\left[\frac{(\mathbf{p}_1\times\mathbf{v}_1)\times\mathbf{p}_2}{p^4c}+\frac{\mathbf{p}_2\times\mathbf{v}_1}{p^2\omega_1}\right]\right\}+$$
$$+\frac{im_1m_2\omega_1\omega_2}{\varepsilon_0 c}\left\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\omega_2 t)\}\left[\frac{\mathbf{p}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p^4c}-\frac{\mathbf{p}_1\times\mathbf{v}_2}{p^2\omega_2}\right]\right\}.$$

The item in the first braces here is the convective derivative. It is null only if velocities coincide ($\Delta\mathbf{v} = 0$) or polarizations are equal ($\Delta\mathbf{p} = 0$). The items in the second the third and the fourth braces are partial derivatives with respect to time. The second item depends on the frequency difference ($\omega_1 - \omega_2$), and correspondingly the third and the fourth ones depend on the product ($\omega_1\cdot\omega_2$). These force amplitudes are defined by vectors in square brackets attached to exponents.

Momentum forces amplitudes are vectors, in contrast to gradient forces which oscillation directions are defined by polarization difference $\Delta\mathbf{p}$. The interaction momentum between photon and electron is a special case of (4.5.19). Let us investigate this case separately because it is connected with famous Compton experiment.

Let $\mathbf{B}_1$ be photon's magnetic field defined by (4.4.2) and $\mathbf{B}_2^*$ be complex conjugate magnetic field of an electron defined by (4.5.4):

$$c\left(\mathbf{B}_1\times\mathbf{B}_2^*\right)=-\frac{\omega_1\omega_2}{c}\left\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\left[\frac{(\mathbf{p}_1\times\mathbf{c}_1)\cdot(\mathbf{p}_2\times\mathbf{v}_2)}{p_1^2p_2^2c^2}+\frac{\mathbf{v}_2\times(\mathbf{p}_1\times\mathbf{c}_1)}{p_1^2c\omega_2}-\frac{\mathbf{c}_1\times(\mathbf{p}_2\times\mathbf{v}_2)}{p_2^2c\omega_1}+\frac{\mathbf{c}_1\times\mathbf{v}_2}{\omega_1\omega_2}\right]+\right.$$
$$\left.+\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\omega_1 t)\}\left[\frac{(\mathbf{p}_1\times\mathbf{c}_1)\times\mathbf{p}_2}{p_1^2p_2^2c}-\frac{\mathbf{p}_2\times\mathbf{c}_1}{p_2^2\omega_1}\right]\right\}. \quad (4.5.21)$$

When triple vector products are revealed, one gets:

$$c\left(\mathbf{B}_1\times\mathbf{B}_2^*\right)=-\frac{\omega_1\omega_2}{c}\left\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\cdot\left[\frac{\mathbf{p}_2(\mathbf{v}_2\cdot(\mathbf{p}_1\times\mathbf{c}_1))-\mathbf{v}_2(\mathbf{p}_2\cdot(\mathbf{p}_1\times\mathbf{c}_1))}{p_1^2p_2^2c^2}+\frac{\mathbf{p}_1(\mathbf{c}_1\cdot\mathbf{v}_2)-\mathbf{c}_1(\mathbf{p}_1\cdot\mathbf{v}_2)}{p_1^2c\omega_2}-\right.\right.$$
$$\left.\left.-\frac{\mathbf{p}_2(\mathbf{c}_1\cdot\mathbf{v}_2)-\mathbf{v}_2(\mathbf{p}_2\cdot\mathbf{v}_1)}{p_2^2c\omega_1}+\frac{\mathbf{c}_1\times\mathbf{v}_2}{\omega_1\omega_2}\right]-\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\omega_1 t)\}\left[\frac{-\mathbf{p}_1(\mathbf{p}_2\cdot\mathbf{c}_1)+\mathbf{c}_1(\mathbf{p}_1\cdot\mathbf{p}_2)}{p_1^2p_2^2c^2}-\frac{\mathbf{p}_2\times\mathbf{c}_1}{p_2^2\omega_1}\right]\right\}. \quad (4.5.22)$$

When Eqs. (4.5.21) and (4.5.22) are multiplied by $(m_1\cdot m_2)/\varepsilon_0$, where m_1 is photon mass, m_2 is electron mass, ε_0 is ether density, they define the momentum increase that the electron transfers to the photon. Because of photon and electron construction,

$$\mathbf{p}_1\perp\mathbf{c}_1,\ \mathbf{p}_2\perp\mathbf{v}_2. \quad (4.5.23)$$

Let us assume in addition that

$$\mathbf{p}_1\,||\,\mathbf{p}_2,\ \mathbf{v}_2\perp\mathbf{c}_1. \quad (4.5.24)$$

Hence and from (4.5.23) condition one gets

$$\mathbf{p}_1\perp\mathbf{v}_2,\ \mathbf{p}_2\perp\mathbf{c}_1. \quad (4.5.25)$$

Taking into account (4.5.23)–(4.5.25), one gets the first square brackets in the right hand part of (4.5.22):

$$[\ ]_1=\left[\mathbf{p}_2\frac{|\mathbf{v}_2||\mathbf{p}_1|\cos\varphi}{p_1^2p_2^2c}+\mathbf{p}_1\frac{|\mathbf{v}_2|}{p_1^2\omega_2}-\mathbf{p}_2\frac{|\mathbf{v}_2|}{p_2^2\omega_1}+\frac{\mathbf{c}_1\times\mathbf{v}_2}{\omega_1\omega_2}\right], \quad (4.5.26)$$

where φ is the angle between $\mathbf{v}_2$ and $(\mathbf{p}_1\times\mathbf{c}_1)$. The second the third and the fourth items here are constant vectors independent with respect to collision angle φ. Only the first item depends on it. When vectors $\mathbf{v}_2$ and $(\mathbf{p}_1\times\mathbf{c}_1)$ are perpendicular, this item is null. All the items depend on photon's characteristics $\mathbf{p}_1$ and ω_1. Let us introduce an additional velocity vector for the photon:

$$\mathbf{v}_1=\frac{\omega_1\mathbf{p}_1}{p_1^2},\ |\mathbf{v}_1|=c. \quad (4.5.27)$$

This is the oscillation velocity for a linearly polarized photon along normal vector $\mathbf{p}_1$. The $\mathbf{v}_1$ designation is introduced in order to distinguish this velocity from the electron translational movement speed $\mathbf{c}_1$.

Let us multiply the square brackets (4.5.26) by the factor $\omega_1\omega_2/c$ standing before the braces. One gets

$$[\ ]_1=\left[-\mathbf{p}_2\frac{|\mathbf{v}_2|\omega_2}{p_2^2c}(1-\cos\varphi)+\mathbf{v}_1\frac{|\mathbf{v}_2|}{c}+\frac{\mathbf{c}_1\times\mathbf{v}_2}{c}\right]. \quad (4.5.28)$$

The coefficient attached to parentheses is proportional to the Compton wavelength of the electron $|\mathbf{R}|=|\mathbf{p}_2/p_2^2|$ and the electron's frequency ω_2. Just this item appears in textbooks where Compton's experiment is explained. Eq. (4.5.28) contains two additional vectors. They define a certain drift in the reflected photons' distribution, *i.e.,* a certain asymmetry in their spatial distribution. This drift is not taken into account when Compton's experiment is described in textbooks as a collision of rigid balls.

One has for the second square brackets

$$[\ ]_2=\left[\mathbf{c}_1+(\mathbf{c}_1\times\mathbf{p}_2)\frac{\omega_2}{p_2^2c}\right]. \tag{4.5.29}$$

These brackets consist only of stable vectors dependent only on photon's movement direction and independent of its individual characteristics: polarization and frequency. One gets finally: the additional momentum transferred by the electron to the photon under the mentioned conditions is

$$\begin{aligned}\Delta\mathbf{P}_{21}&=\frac{cm_1m_2}{\varepsilon_0}\left(\mathbf{B}_1\times\mathbf{B}_2^*\right)=\frac{m_1m_2}{\varepsilon_0}\left\{\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\cdot\left[\mathbf{p}_2\frac{|\mathbf{v}_2|\omega_2}{p_2^2c}(1-\cos\varphi)+\mathbf{v}_1\frac{|\mathbf{v}_2|}{c}+\frac{\mathbf{c}_1\times\mathbf{v}_2}{c}\right]-\right.\\&\left.-\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega_1t)\}\cdot\left[\mathbf{c}_1+(\mathbf{c}_1\times\mathbf{p}_2)\frac{\omega_2}{p_2^2c}\right]\right\}.\end{aligned} \tag{4.5.30}$$

The normal vector drift whose modulus define wave length drift is obtained if (4.5.30) is divided by $(m_1m_2|\mathbf{v}_2|\omega_2)/(\varepsilon_0c)$:

$$\Delta\mathbf{P}_{21}=\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega t)\}\cdot\left[\frac{\mathbf{p}_2}{p_2^2c}(1-\cos\varphi)+\frac{\mathbf{v}_1}{\omega_2}+\frac{\mathbf{c}_1\times\mathbf{v}_2}{|\mathbf{v}_2|\omega_2}\right]-\exp\{i(\Delta\mathbf{p}\cdot\mathbf{r}-\Delta\omega_1t)\}\cdot\left[\mathbf{c}_1+(\mathbf{c}_1\times\mathbf{p}_2)\frac{1}{p_2^2|\mathbf{v}_2|}\right]. \tag{4.5.31}$$

The vectors in square brackets define oscillation amplitudes of the exponents attached to them. The physical meaning of the first brackets has been already discussed. The second oscillation is directed "forward" along the photon's velocity vector $\mathbf{c}_1$ and perpendicular to it. This interpretation is not accurate, because of simplifying conditions (4.5.24) assumed above. In the general case, the (4.5.22) "side oscillation" is weakened because in general $\mathbf{c}_1$ and $\mathbf{v}_2$, $\mathbf{c}_1$ and $\mathbf{p}_2$ are not perpendicular.

4.6. Conclusion

Let us summarize the main results. The wave solution for the Generalized Maxwell equations led us to the concept of the wave created by a moving electron as an essentially three-dimensional torsional oscillation. This oscillation takes place in longitudinal (along speed) and transverse (perpendicular) directions. This oscillation defines a traveling wave with amplitudes in longitudinal and transverse directions that are connected. Therefore, suppression of oscillation in one direction leads to suppression of oscillation in the other direction.

In addition to this two-dimensional oscillation, the electron's wave oscillates in the third dimension creating a standing wave independent with respect to time and the electron's own movement, in contrast to the above mentioned-traveling wave. This standing wave defines the electron's charge and Coulomb interaction force with other charges. Therefore the Coulomb force turns to be a long range one, in contrast to the Lorentz force, which is defined by a traveling wave that moves with electron's velocity. One can say this in another way. The wave creating Coulomb force exists I ether from time immemorial. But the generalized Lorentz force is generated by movement and disappears with it. A positron possesses a similar standing wave with opposite sign. In an electron-positron collision, the standing waves are mutually annihilated, which means charge annihilation.

These waves can appear only being "repulsed" by each other. Therefore electric charges appear only in couples: positive and negative ones. A certain visual notion about the electron as a massive torus rotating in equatorial and meridional planes is proposed. Charge magnitude is defined by the electron's mass and the angular velocity of its equatorial rotation. If it constitutes right hand screw with meridional angle velocity, one gets charge of one sign, and of opposite sign in the opposite case. This screw also defines the sign of the above-mentioned standing wave.

Charge is vector modulo stable and directed along the greater circumference radius. It can be directed either in or out of the circumference. Therefore it can be described by scalar. Charge is an inner characteristic of electron independent of its movement.
The electron's spin is proportional to its meridional angular velocity. It is also a vector taking only two values depending on the screw it constitutes with the electron's velocity. Therefore the currently accepted spin definition as a vector with discrete projections on any direction in space looks doubtful. Spin also characterizes the electron, but reveals itself only in movement. In other words, spin is an external, dynamic characteristic of the electron.

The photon does not possess charge, *i.e.,* it does not have equatorial rotation. It can be imagined as a cylinder moving along its axis and performing longitudinal and in general torsion oscillations along its directrix.

In particular, for linearly polarized light, these torsion oscillations become transverse. The photon's movement is completely similar to an electron's traveling wave. In other words, the photon is a two-dimensional object, in contrast to the electron. One can say that the photon is a longitudinally oscillating vortex carrying mass with light velocity. The photon's energy redoubling (mc^2 instead of $\frac{1}{2}mc^2$) becomes understandable: in every oscillation, longitudinal and torsion halves add to the total sum.

For the same reason, the two-dimensional wave of a moving electron possesses mv^2 and not ½mv^2 energy. In the third direction, oscillation gives redoubled energy ½mc^2 because magnetic and electric fields are parallel in this direction.

Oscillations of elementary particles are described with essential utilization of complex functions. Essential utilization means that if we limited ourselves to only real parts, we would not only complicate computations (as textbooks often assert), but we would also not get correspondence to experiment. In other words, imaginary parts of electric and magnetic fields contribute to energy and momentum of elementary particles. Therefore, the electron and photon models as torus and cylinder are conventional. We shall not get their adequate description if we don't take into consideration their rotation in complex plane, or perhaps their movement in the space of quaternions.

The last Sections of the article are devoted to interactions of elementary particles. Such interaction turns out to be wave-like as well. Interaction and oscilations in ensembles of particles are null only between coherent photons with codirected spins. Such photons fly in parallel lines. In general photon beams diverge because of such oscillations. Photons interfere, and this is interpreted today as a wave quality of individual photons. Individual photons oscillate and possesses wave quality, but not because photons ensembles oscillate.

The derived results naturally explain some difficult problems of modern quantum mechanics such as the electron's self-action, its energy infinity, electromagnetic mass, etc. In philosophical aspect, the proposed approach is very close to Newtonian light corpuscular ideas, sometimes even in its details.

CHAPTER 2: GRAVIDYNAMICS

5. Preface to Chapter 2

General Relativity Theory considers gravity as a very special type of field. They believe that gravity curves space in contrast to other fields, electricity in particular. Epigoni prescribe additional qualities to it for instance space twisting.

Such postulates actually makes impossible to find analogy between gravity and electricity and excludes this powerful method of investigation. Meanwhile analogy often helps us to link different areas of science which previously seemed very far from each other. Philosophically analogy reflects our belief into fundamental unity of universe.

Today understanding of gravity seems especially strange because electricity and gravity are evidently similar, it is sufficient to compare Coulomb and Newton laws. Certainly this fact is evident. And Einstein himself understood this when he transformed the problem of Lorentz invariance for velocities in electrodynamics for invariance for accelerations in gravity.

Apparently other scientists including Weber went more natural path: gravity dynamic formulas for electric charges they tried to expand on. This problem is considered in grater details in §8. These section the greater part of the scientists (if not all) considered gravity as a special type of electrodynamics values (§3, previous section) clears up the problem: gravity has dimension of acceleration. Thus it must be generated by mass moving with acceleration. Electric field has dimension of velocity. It is determined by electric charge velocity. One can say that electricity is velocity field and gravity is acceleration field or the same in other wards: gravity is described by Maxwell type equations with the second time derivative and light velocity (sound speed in ether) must be changed for another constant, the acceleration with which gravitational field moves in ether.

And how electric field is connected with gravity? The answer is given by electric charge dimension kg·rad/s, *i.e.,* it is the mass changing speed. Therefore electric charge movement originates in ether the same effects as mass moving with acceleration. In other words electricity may be considered as a special case of gravity.

I'd like to attract the reader's attention to one problem in addition. Vertical movement of the mass originating electric charge leads to creation charges of two types: with left- and right-handed rotation. And this yields the problem which confused many scientists and Maxwell in particular: two similar electric charges are repelled and two masses are attracted. Formula for generalized Lorentz force (2.2.1) takes this into account: not two electric fields but electric field of one charge and magnetic field of another charge figure in static part of the formula. But two gravitational fields appear in the corresponding formula for gravitational force.

Gravidynamic force formula has turned to be much more cumbrous than generalized Lorentz one. It is understandable mathematically: the second derivative is always more bulky than the first one. The problem is in physical sense of these additional items. Apparently "dark matter", Pioneer-11 and Pioneer-12 problems, accelerated movement of galaxies and many other gravitational effects are linked with the second, third and fourth derivatives appearing in the gravidynamic force formula.

6. Maxwell's Approach to Gravity

Chronologically this investigation appeared earlier than the other parts of this book. At that time this author had not yet realized the importance of total time derivatives in fields' description. Therefore partial time derivative figure in eq. (6.1.4)–(6.1.7) below, although gravitational current is defined as the total time derivative. Only later the essence of the total time derivative was understood. This understanding was embodied in gravidynamic force description [§8]. All the results of §6 and §7 can be obtained as corollaries of §8.

It was decided to include §6 and §7 into this book because they contain some actual problems of modern gravitational theory. And perhaps not all our reader have time and endurance to obtain the corresponding assertions from §8. It addition §6 and §7 are natural introduction to formal calculations in §8.

This below equations of gravidynamic field with partial time derivatives are written. They were obtained by this author on the basis of variational "Logarithm Principle" [29] proposed earlier are similar to the Maxwell equations for electric field. Imply three experiments now considered as proof of general relativity are investigated in "*Maxwell's Approach to Gravity*". In addition they give a uniform explanation of some facts which now are explained at all.

They are: Phobos falling on Mars, the differential rotation of the Sun and gasoliquid planets, the proximity of natural satellites' orbits to equatorial planes of central bodies, the Earth's continental drift, the observed type of atmosphere and ocean currents, the source of energy for the Earth's magnetic field etc.

Authors "Logarithm principle" [29] gives a possibility to write out the equations of the field of gravity which are investigated here. These equations are partly similar to that of Maxwell for electric field. They imply three facts now considered as experimental proof of general relativity theory, that is: rotation of planets' perihelium, gravitational red shift, and ray deviation in the Sun field. In addition they give a uniform explanation of some facts which now are explained ad hoc or are not explained at all. They are: Phobos falling on Mars, the differential rotation of the Sun and gasoliquid planets, the proximity of natural satellites' orbits to equatorial plane of the central body, the Earth's continental drifts, the observed type of atmosphere and ocean currents, the source of energy for Earth's magnetic field, etc. The physical and mathematical meaning of Bohr's orbits of electrons in atoms, the dynamics of the solar system development becomes clearer. One can surely assert that the field we now call nuclear is at least partially gravitational.

6.1. The Main Equations

The "logarithm principle" implies that **A** and φ satisfies the following equations:

$$\nabla\cdot\nabla\mathbf{A}-\frac{1}{a^2}\frac{\partial^4\mathbf{A}}{\partial t^4}=-\frac{4\pi\gamma\mathbf{j}}{a^2}, \tag{6.1.1}$$

$$\nabla\cdot\nabla\varphi-\frac{1}{a^2}\frac{\partial^4\varphi}{\partial t^4}=-4\pi\gamma\rho. \tag{6.1.2}$$

Here γ is a gravitational constant, a = const is the acceleration of graviton, **j** is tensity of gravitational current, ρ is mass density. Mass is considered as a gravitational charge. For a certain period it will be more convenient for us to work with the Maxwell form of the equations (6.1.1) and (6.1.2). In order to transfer to that form let us adopt the following calibrate condition:

$$\nabla\cdot\mathbf{A}=-\frac{1}{a^2}\frac{\partial^2\varphi}{\partial t^2}. \tag{6.1.3}$$

Let us designate the tensity of the gravitational field as:

$$\mathbf{G}=-\nabla\varphi-\frac{\partial^2\mathbf{A}}{\partial t^2}, \tag{6.1.3a}$$

the tensity of the gravimagnetic field:

$$\mathbf{D}=\nabla\times\mathbf{A}. \tag{6.1.3b}$$

Taking into account (6.1.3), (6.1.3a), (6.1.3b) one could easily show by direct substitution that (6.1.1) and (6.1.2) are equivalent to the following system of equations:

$$\nabla\cdot\mathbf{G}=4\pi\gamma\rho, \tag{6.1.4}$$

$$\nabla\times\mathbf{G}=-\frac{\partial^2\mathbf{D}}{\partial t^2}, \tag{6.1.5}$$

$$\nabla\cdot\mathbf{D}=0, \tag{6.1.6}$$

$$a^2\nabla\times\mathbf{D}=4\pi\gamma\mathbf{j}+\frac{\partial^2\mathbf{G}}{\partial^2 t}. \tag{6.1.7}$$

G has a dimension of acceleration m/s², **D** is a nondimensional quantity, gravicurrent **J** has the dimension of force kg·m/s and its density **j** has the dimension kg/m²s².

The system of equations (6.1.4)–(6.1.7) differs from the Maxwell equations, in that the second time derivatives instead of the first ones figure in it. Let us investigate the gravistatic and gravimagnetostatic case, in which time derivatives are equal to zero. If so, the first two equalities will be:

$$\begin{cases}\nabla\cdot\mathbf{G}=4\pi\gamma\rho\\ \nabla\times\mathbf{G}=0\end{cases}. \tag{6.1.8}$$

It is well known that the system (6.1.8) is equal to the law of universal gravity and that

$$G=\frac{\gamma M}{r^2}.$$

where M is the mass creating gravifield, r is the distance. In general, the force vector will be defined by a relation similar to the Lorentz force for the electromagnetic field:

$$\mathbf{F}=m\mathbf{G}+\mathbf{J}\times\mathbf{D}. \tag{6.1.9}$$

If a gravifield **G** and gravimagnetic field **B** are created at the point where mass m is situated, and mass m creates gravicurrent **J** then the force (6.1.9) acts on it.

The system

$$\begin{cases}\nabla\cdot\mathbf{D}=0\\ a^2\nabla\times\mathbf{D}=4\pi\gamma\mathbf{j}\end{cases} \tag{6.1.10}$$

describes the case of gravimagnetostatics if **j** is a constant of time. It is necessary to clear up the physical sense of gravicurrent in order to work with it. Historically, the concept of electric current was formed as a result of a lot of experiments. Nevertheless, it is possible to define it axiomatically.

The Maxwell equations imply the following equality for tensity of electric current $\mathbf{j}_e$ and density of electric charge ρ_e:

$$\frac{\partial\rho_e}{\partial t}+\nabla\cdot\mathbf{j}_e=0, \tag{6.1.11}$$

But $\mathbf{j}_e=\rho_e\mathbf{v}$, that's why equality (6.1.11) may be considered as a condition of preserving charge

$$\frac{d\rho_e}{dt}=0. \tag{6.1.12}$$

Density of electric current may be defined as a function satisfying this condition because of correlation (6.1.12).

We shall follow the same pattern. The equations (6.1.4)–(6.1.7) imply

$$\frac{\partial^2\rho}{\partial t^2}+\nabla\cdot\mathbf{j}=0. \tag{6.1.13}$$

The analogue of the correlation (6.1.11) is the equation

$$\frac{d^2\rho}{dt^2}=0. \tag{6.1.14}$$

This may be called the "law of constant velocity of gravicharge alteration".

Definition. Function **j** is called density of gravicurrent if it satisfies equalities (6.1.13)–(6.1.14).

$$\begin{aligned}\frac{d^2\rho}{dt^2}=\ddot\rho+2\sum_{i=1}^{3}\dot\rho'_{x_i}v_i+\sum_{i=1}^{3}\rho'_{x_i}\dot v_i+\\ +\sum_{i=1}^{3}\sum_{k=1}^{3}(\rho'_{x_i}v'_{ix_k}v_k)+\sum_{i=1}^{3}\sum_{k=1}^{3}(\rho''_{x_ix_k}v_iv_k).\end{aligned} \tag{6.1.14a}$$

The lower index here refers to the corresponding partial derivative

In view of (6.1.13) one gets with accuracy of rot of a function

$$\mathbf{j}=2\dot\rho\mathbf{v}+\rho\dot{\mathbf{v}}+\rho\sum_{i=1}^{3}v_i\mathbf{v}'_{x_i}+(\nabla\rho\cdot\mathbf{v})\mathbf{v}. \tag{6.1.15}$$

By integrating both parts of the equation over volume one gets the expression for gravicurrent

$$\mathbf{J} = 2\dot{m}\mathbf{v} + m\dot{\mathbf{v}} + m\sum_{i=1}^{3} v_i \mathbf{v}'_{x_i} + (\nabla m \cdot \mathbf{v})\mathbf{v}. \qquad (6.1.15a)$$

Here m is the mass contained in the volume of integration.

Eq. (6.1.4) involves:

$$\frac{dm}{dt} = e = \text{const}. \qquad (6.1.16)$$

Assumption. Constant e in (6.1.16) is electric charge of electron.

It is evident that an electric charge has dimension kg/s. Let us note that in this case electric field tensity in Maxwell equations has a dimension of velocity m/s and magnetic field is nondimensional just as in the case of a gravifield.

6.2. Examples of Gravicurrent

The sense of the items in (6.1.15) and (6.1.15*a*) is cleared here up by examples.

The first item $\mathbf{J}_2$ in (6.1.15*a*) is simply doubled reactive force, whose meaning is widely known. In order to clear up the following two items $\mathbf{J}_2$ and $\mathbf{J}_2$ let us investigate the movement of a planet around the Sun.

Example 1

Let the plane of the planet's orbit coincide with the plane of the Sun's equator (X_1X_2) and the beginning of the coordinate system is situated in the baricentre of the Sun. The velocity vector

$$\mathbf{v} = \omega \times \mathbf{R}, \qquad (6.2.1)$$

where $\boldsymbol{\omega}$ is the vector of angular velocity and $\mathbf{R}$ is the radius-vector. Differentiating in time one gets:

$$\dot{\mathbf{v}} = \tau = \varepsilon \times \mathbf{R} + \omega \times \dot{\mathbf{R}}, \qquad (6.2.2)$$

where $\boldsymbol{\varepsilon}$ is angular acceleration, $\dot{\mathbf{R}}$ is velocity of changing radius vector. So the second item $\mathbf{J}_2$ in (6.1.15*a*) for our example is the tangential force.

In general this is the force in the second Newton's law

$$\mathbf{J}_2 = m\dot{\mathbf{v}} = m\tau. \qquad (6.2.3)$$

The sum

$$\mathbf{J}_1 + \mathbf{J}_2 = \dot{m}\mathbf{v} + m\dot{\mathbf{v}} \qquad (6.2.4)$$

is the force in the second Newton's law

Here the first item is the reactive force (not doubled).

Let us differentiate the planet's velocity in coordinates in order to find the third item $\mathbf{J}_3$.

$$\begin{aligned} &\mathbf{v}'_{x_1} = (0,\ +\omega), \quad v_1\mathbf{v}'_{x_1} = (0,\ -x_2\omega^2), \\ &\mathbf{v}'_{x_2} = (-\omega,\ 0), \quad v_2\mathbf{v}'_{x_2} = (-x_1\omega^2,\ 0), \\ &v_1\mathbf{v}'_{x_1} + v_2\mathbf{v}'_{x_2} = -\omega^2(x_1,\ x_2). \end{aligned} \qquad (6.2.5)$$

We received the resulting expression which is simply centripetal acceleration, and the third item is centripetal force

$$\mathbf{J}_3 = -m\omega^2\mathbf{R}. \qquad (6.2.6)$$

Example 2

There is density gradient in the fourth item of (6.1.15).

In order to illustrate the physical essence of $\mathbf{j}_4$ let us consider a plane massive disc rotating in plane (X_1X_2) around its center situated in the beginning of a system of coordinates. Let the density linearly decrease from the center of the disc:

$$\begin{aligned} &\rho = \rho_0 - \alpha(x_1 + x_2),\ \rho_0,\ \alpha = \text{const}. \\ &\nabla\rho = -\alpha(1,\ 1), \\ &\nabla\rho \cdot \mathbf{v} = -\alpha(v_1 + v_2), \end{aligned} \qquad (6.2.7)$$

$$\mathbf{j}_4 = -\alpha(v_1 + v_2)\mathbf{v} = +\alpha\omega(x_2 - x_1)\mathbf{v}. \qquad (6.2.8)$$

Expression (6.2.8) defines tangential forces (fig. 6.2.1).

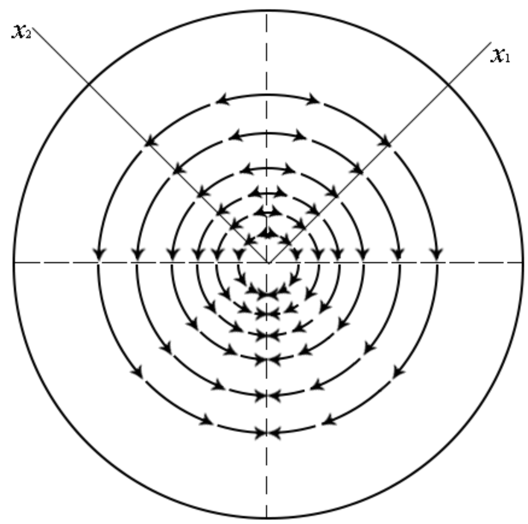
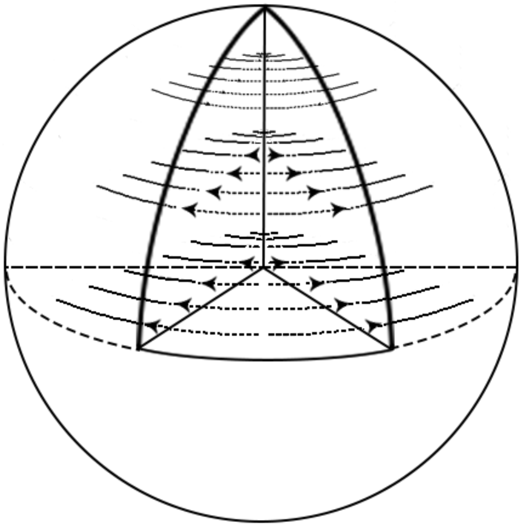
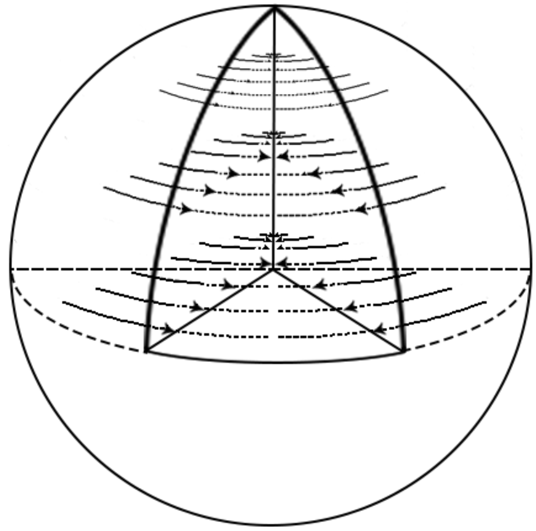


Fig. 6.2.1

Line $x_2 = x_1$ is the line of zero forces. Module equal and oppositely directed forces act in half planes $x_2 >(<) x_1$. Line $x_2 = -x_1$ is the line where these forces grow module maximum. One could say that the forces flow out of a positive half-line $x_2 = x_1$, $x_1x_2 \geq 0$ in opposite directions (this half-line is called the source (fig. 6.2.2, a)) and flows in a half-line $x_2 = x_1$, $x_1x_2 < 0$ (this half-line is called the drainer (fig. 6.2.2, *b*)).



a



b

Fig. 6.2.2

Let us consider a ball instead of the disc, rotating around the x_3 axis:

$$\rho = \rho_0 - \alpha(x_1 + x_2 + x_3),\ \alpha,\ \rho_0 = \text{const},$$
$$\nabla\rho = -\alpha(1,\ 1,\ 1),$$
$$\mathbf{j}_4 = -\alpha(v_1 + v_2 + v_3)\mathbf{v},$$
$$v_3 = 0.$$

That's why the rotation of such a ball may be stratum by stratum reduced to a plane case.

The geometric place of points of zero forces is the plane going through x_3 axis and the line $x_2 = x_1$. The distance from x_3 axis to the ball surface in planes perpendicular to x_3 axis decreases according to cosine law. If the density gradient decreases in the same way then the forces on the ball surface decreases according to square cosine law.

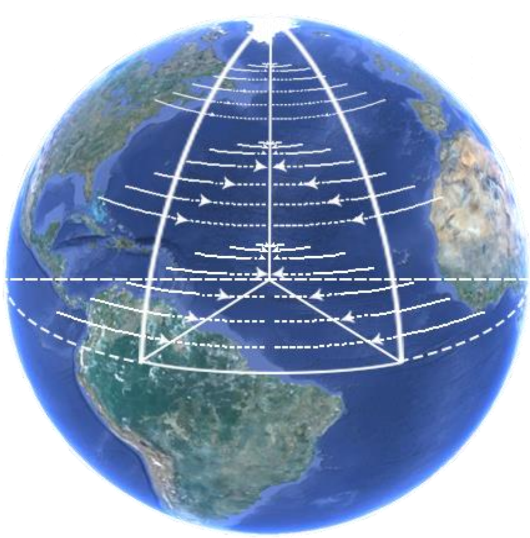
This is manifested for instance in the differential rotation of the Sun and gasoliquid planets. The above mentioned force on the Earth is one of the forces giving birth to the continental drift, ocean and atmospheric streams. The following example illustrates this qualitative assertion.

Example 3

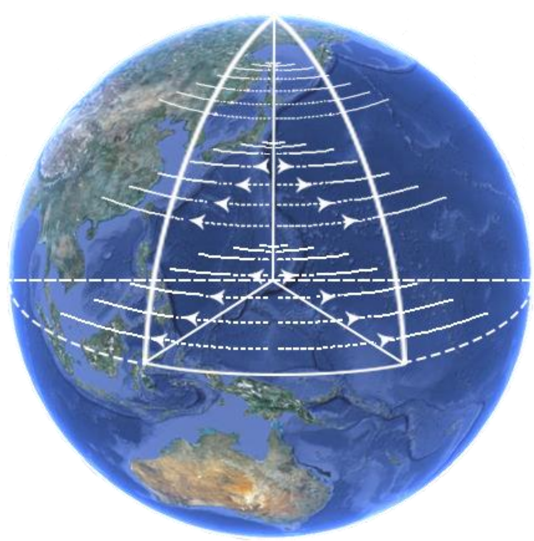
Let the origin of a system of coordinates be in barycenter of the Earth, axis x_3 be directed to the North along the axis of the Earth's rotation. If so, (X_1X_2) axes turn out to be in the equatorial plane. Data on the continental drift show that the source of gradient forces on the Earth is the meridian of the rift valley in the Atlantic Ocean (fig. 6.2.3, a), and the drainer is the meridian of the Kurile Islands (fig. 6.2.3, b). Let us put the (X_1X_2) axis in spherical coordinates:

$$x_1 = R\cos\theta\sin\varphi,\ x_2 = R\sin\theta\sin\varphi,\ x_3 = R\cos\varphi\,.$$

The Kurile Islands' meridian corresponds to the angle $\theta = 45°$.



a



b

Fig. 6.2.3

The velocity of surface water because of the Earth's rotation is:

$$\mathbf{v} = \omega \times \mathbf{R}, \tag{6.2.9}$$

where $\boldsymbol{\omega}$ is the angular velocity vector of the Earth own rotation, $\mathbf{R}$ is radius-vector;

$$\begin{aligned}
&v_1 = \omega_2 R\cos\varphi - \omega_3 R\cos\theta\sin\varphi,\\
&v_2 = \omega_3 R\sin\theta\sin\varphi - \omega_1 R\cos\varphi,\\
&v_3 = \omega_1 R\sin\theta\sin\varphi - \omega_2 R\cos\theta\sin\varphi,\\
&v_1 + v_2 + v_3 = R[\omega_1(\sin\theta\sin\varphi - \cos\varphi) +\\
&+\omega_2(\cos\varphi - \cos\theta\sin\varphi) + \omega_3\sin\varphi(\cos\theta - \sin\theta)].
\end{aligned} \tag{6.2.10}$$

Let us suppose that when $\varphi \in [0, \pi/2]$ the surface water density decreases according to cosine law because of the temperature increasing in movement from the North pole to the Equator, and then when $\varphi \in [\pi/2, \pi]$ it increases in accordance with the same law. This means that ρ is linear to x_3.

If ρ is also linear to x_1 and x_2 (*i.e.,* linearly grows with the depth and not essentially depends on θ), then

$$\nabla\rho = -C_4(1,\ 1,\ 1). \tag{6.2.11}$$

Gradient force

$$\mathbf{F} = (\nabla\rho\cdot\mathbf{v})\mathbf{v}.$$

Taking into account (6.2.4) and the fact that $\omega_1 = \omega_2 = 0$, $\omega_3 = \text{const}$

$$\nabla\rho\cdot\mathbf{v} = -C_4 R\omega_3\sin^2\varphi(\cos\theta - \sin\theta).$$

Let

$$C_1 = -C_4 R\omega_3.$$

Then the quantity of force

$$F_1 = +C_1\sin^2\varphi(\sin\theta - \cos\theta). \tag{6.2.12}$$

The origin of this force is the Kurile meridian and the drainer is the Rift Valley in the Atlantic Ocean. When $\theta \in [\pi/4,\ 5\pi/4]$ (from the Kurile meridian over Pacific Ocean up to the Rift Valley) the gradient force (6.2.6) is positive and directed to the East. When $\theta \in [\pi/4,\ -3\pi/4]$ (from the Kurile meridian over the Indian Ocean up to the Rift Valley) it is negative and directed to the West. But this force is not unique. Later on we shall consider a force created by the gravimagnetic field of the Sun and planets and investigate some effects revealing it in outer space. The distribution of this force in the mass of celestial bodies are not known and should be investigated with greater precision later. Now it is supposed that the distribution of this force over the Earth surface water is as follows:

$$F_2 = -C_2 + C_3\sin 6\varphi,\ C_2, C_3 = \text{const}.$$

The sign minus before C_2 means that constant in space (but not in time) component of this force is directed today against the Earth's own rotation. This in particular means that the Earth is slowing down its own rotation.

The force

$$F = F_1 + F_2 = C_1\sin^2\varphi(\sin\theta - \cos\theta) - C_2 + C_3\sin 6\varphi.$$

acts on surface water.

The author does not have the experimental data at his disposal to evaluate constants C_1, C_2, C_3. But these constants must have opposite's signs in the Northern and Southern hemispheres.

Therefore a picture of relative intensities of ocean currents is investigated here. It is supposed that in the Southern hemispheres

$$C_1 = C_3 = 2C_2 = 1.$$

This normed force is

$$F = \sin^2\varphi(\sin\theta - \cos\theta) - 0.5 + \sin 6\varphi.$$

Let us find the magnitude of this force in the southern hemisphere $\varphi \in [\pi/2, \pi]$, when $\theta = \pi$, *i.e.,* when $\sin\theta - \cos\theta = 1$

$$F(\varphi = 90^\circ) = 0.5.$$

This force is directed East along the equator and creates an equatorial anticurrent in the Pacific ocean.

$$F(\varphi = 94.92^\circ) = 0.$$

That is intensity of the equatorial anticurrent grows equal to zero approximately at 4.92° of S. Lat.

Further on the force changes its sign and reaches at 15° of S. Lat.

$$F(\varphi = 105^\circ) = -0.57,$$

and again becomes equal to zero at 27.2° S. Lat.

$$F(\varphi = 117.2^\circ) = 0.$$

Thus this force in the span from 4.92° S. Lat. to 27.2° S. Lat. is directed to the West and creates a southern equatorial current in the Pacific Ocean.

Further on the force changes its mathematic sign again, reaches at 45° of S. Lat.

$$F(\varphi = 135^\circ) = 1.$$

This force creates an Antarctic circumpolar current that grows equal to zero at 57.9° of S. Lat.

$$F(\varphi = 147.9^\circ) = 0,$$

and again changes its sign creating Antarctic coastal current. We observe the same picture in the Northern hemisphere but with the opposites sign.

If $\theta = -\pi/2$ (Indian Ocean) one has (we took the following constant $C_1 = 4$, $C_2 = 3$, $C_3 = 0.5$)

$$F(\varphi = 90^\circ) = 1.$$

There is no equatorial anticurrent because gravimagnetic and gradient forces are directed in the same way (*i.e.,* to the West)

$$\begin{gathered}
F(\varphi = 100.177^\circ) = 0,\\
F(\varphi = 105^\circ) = 0.27,\\
F(\varphi = 120^\circ) = 0,\\
F(\varphi = 130^\circ) = 0.21.
\end{gathered}$$

Thus the picture of currents in the Indian Ocean qualitatively repeats the current distribution in the Pacific Ocean. It must be mirrored in the northern hemisphere. It corresponds to reality except the northern part of the Indian Ocean where instead of a northern equatorial current directed to the West there exists in reality a current of nonregular form directed to the East. One could suppose that the reason for this is the fact that this region consumes a greater part of the Sun's energy than the equatorial region. Thus the water temperature here is higher than at the equator and the gradient's sign is opposite to the supposed above.

It is necessary to discuss the problem of meridian currents separately. They appear because in addition to the above mentioned forces the Corioli's force also affects the water. The water mass affected by Coriolis force is directed to the South in the Southern hemisphere and to North in the Northern hemisphere if it moves West and in the opposite direction if it moves East.

Let us investigate the problem at example of Golfstream.

Gradient forces are weak in the Atlantic Ocean. Therefore one can take into account only gravimagnetic force which is directed to the West along the equator. This force throws the Gulfstream on to the shore of America. In the Western hemisphere we took the following constant $C_2 = 1.6$.

$$F(\theta = 0°, \varphi = 90°) = -2.3.$$

It reaches at 15° N. Lat (φ = 75°).

$$F(\theta = -60°, \varphi = 75°) = -1.02.$$

and falls up to the zero at 41° N. Lat (φ = 49°).

$$F(\theta = -76.5°, \varphi = 49°) = 0.$$

Further it changes its sign, turns eastward and reaches at 45° N. Lat (φ = 45°).

$$F(\theta = -45°, \varphi = 45°) = 0.41.$$

This force throws Gulfstream on to European shore. Speed molecules attain the shore of Southern France and Spain and moves to the South affected by Coriolis force.

More slow molecules reach Scandinavia and round the peninsular. The warm water of the Gulfstream is quickly dissolved when it meets the growing resistance of gradient forces in Northern seas.

In fig. 6.2.4 we show rather sufficient correspondence of our picture with real geographic observations. F symbolizes the module and direction the forces predicted by our formulas.

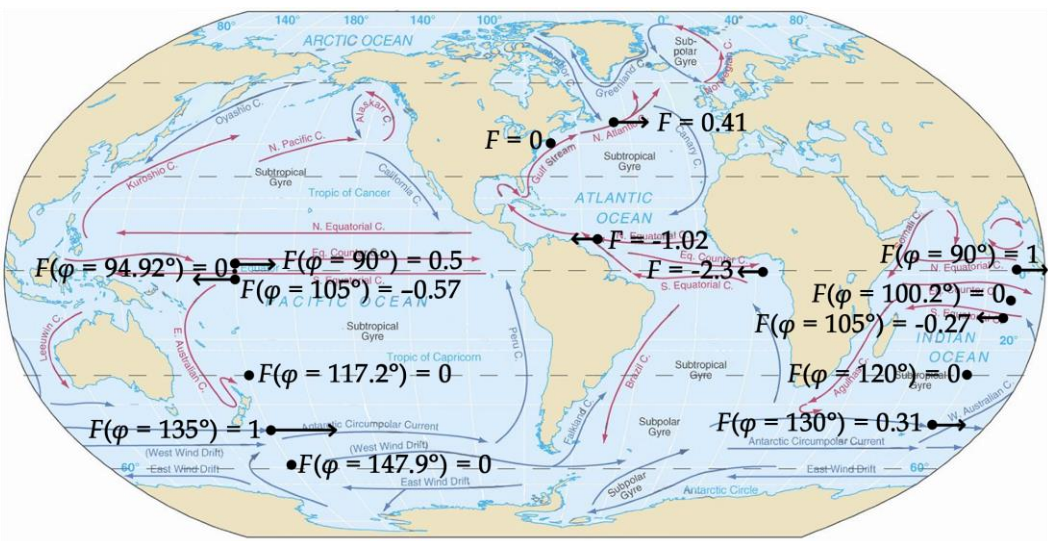


Fig. 6.2.4

6.3. The Gravimagnetic Field

The formula (6.1.7) involves that gravicurrent and accelerated change of gravitense leads to circulation of gravimagnetic field. Let us investigate two examples.

Let a cylinder of mass m and length l move with constant acceleration $\dot{\mathbf{v}} = \text{const}$. The gravimagnetic field originated by such gravicurrent will be described by (6.1.10) equation. This is the case of gravistatics. The same reason as in the case of an electric field leads us to the conclusion that the gravimagnetic field created by this gravicurrent circulates over a circumference around the cylinder. This is the precise analogue of constant electric current. Gravimagnetic current is

$$\mathbf{J} = m\dot{\mathbf{v}}. \qquad (6.3.1)$$

The magnitude of the gravimagnetic field created by this current at distance r is equal to

$$\mathbf{B} = \frac{\gamma m \dot{\mathbf{v}}}{2\pi r l a^2}. \qquad (6.3.2)$$

If parallel to this cylinder another such cylinder moves at distance r, then the force

$$F = \frac{\gamma m^2 \dot{v}_1^2 \dot{v}_2^2}{2\pi r l a^2}. \qquad (6.3.3)$$

affects it in correspondence with correlation (6.1.9).

Example 2

Let gravimagnetic current force **I** circulates over a loop square S creating gravimagnetic dipole moment $\boldsymbol{\mu}$. For electric field

$$\mu = \mathbf{I}S. \tag{6.3.4}$$

It will be shown in the last chapters of this paper that generally speaking it is not so for a gravifield. The correlation close to (6.3.4) holds only for small enough angular velocity. When angular velocity is high enough exponential growth of $\boldsymbol{\mu}$ begins. This also relates to oscillation of cylinders. If

$$\dot{v} = b\omega^2 \cos\omega t, \tag{6.3.5}$$

where b is amplitude, ω is angular velocity of oscillation for two cylinders oscillating in phase, then the ratio for additional force

$$F = \frac{\gamma b^2 m^2 \omega^4 \cos\omega t}{2\pi a^2 r l},$$

which one could get by direct substitution of (6.3.5) into (6.3.3) is true only for ω small enough.

Assumption. Dipole vector gravipotential in outer space at distances great enough is of the same type as dipole vector potential of electric field:

$$\mathbf{A} = \frac{\gamma}{a^2 r^3}\mu \times \mathbf{r}. \tag{6.3.6}$$

This assumption will be accurately proved in section 8.

One gets a gravimagnetic field having taken rotor of expression (6.3.6). It is in projections:

$$\begin{aligned} B_{x_1} &= \frac{\gamma\mu}{a^2}\cdot\frac{3x_1x_2}{r^5}; \\ B_{x_2} &= \frac{\gamma\mu}{a^2}\cdot\frac{3x_2x_3}{r^5}; \\ B_{x_3} &= -\frac{\gamma\mu}{a^2}\cdot\left(\frac{1}{r^3} - \frac{3x_3^2}{r^5}\right). \end{aligned} \tag{6.3.7}$$

The projections of vector **B** are designated here by lower index.

It is supposed that the loop is situated in the (X_1X_2) plane with the center in the origin of the coordinates.

6.4. Cosmic Manifestation of Gravimagnetic Field

There is a reason to believe that electric ferromagnetism which is if not a seldom then at least a peculiar property of substance is much more typical for a gravifield. It will take much time to explain its origins. Here we will restrict ourselves to a

Assumption. All massive bodies are graviferromagnetics.

In particular it is supposed that elementary gravicurrents in macrobodies are in accordance and celestial bodies which are investigated in this paragraph can be considered as gravimagnetic dipoles originating the gravimagnetic field in accordance with (6.3.7).

Let us investigate some corollaries of such a supposition and return to example 1. It is supposed that the Sun gravimagnetic moment is directed in a positive direction along x_3 axis which originates so that planet movement takes place against the clock arrow (as it is in the real Sun system).

What additional forces does it originate except the Newton's one?

The second and the third items in (6.1.15) are not zero for the planet. Therefore, the existence of the Sun dipole gravimagnetic field leads to the appearance of two additional forces. The first of these is

$$\mathbf{F}^{(2)} = \mathbf{J}_2 \times \mathbf{B} = m\tau \times \mathbf{B}. \tag{6.4.1}$$

B is the Sun dipole gravimagnetic field here defined by (6.3.7).

This force in coordinate form for the planet rotating in arbitrary plane looks as follows:

$$\begin{aligned} F_1^{(2)} &= m(\tau_2 B_3 - \tau_3 B_2); \\ F_2^{(2)} &= m(\tau_3 B_1 - \tau_1 B_3); \\ F_3^{(2)} &= m(\tau_2 B_1 - \tau_1 B_2). \end{aligned} \tag{6.4.1a}$$

In particular, the planet rotating in the plane of the Sun's equator is affected by radial force

$$\begin{aligned} F_1^{(2)} &= m\tau_2 B_3 = -\frac{\gamma\mu m}{a^2 r^3}(\varepsilon_3 x_1 + \omega_3 \dot{x}_1); \\ F_2^{(2)} &= -m\tau_1 B_3 = -\frac{\gamma\mu m}{a^2 r^3}(\varepsilon_3 x_2 + \omega_3 \dot{x}_2); \\ F_3^{(2)} &= 0. \end{aligned}$$

The centripetal acceleration in the field **B** also originates additional force

$$\mathbf{F}^{(3)} = \mathbf{J}_3 \times \mathbf{B}, \tag{6.4.2}$$

or in ordinates form

$$\begin{aligned} F_1^{(3)} &= -\frac{\gamma\mu m\omega^2}{a^2 r^3}x_2; \\ F_2^{(2)} &= +\frac{\gamma\mu m\omega^2}{a^2 r^3}x_1; \\ F_3^{(2)} &= 0. \end{aligned} \tag{6.4.3}$$

Thus centripetal force effecting planet in the Sun gravimagnetic field originates tangent force which either "untwist" or brake the planet rotation depending on μ sign. One should reasonably assert that namely this force brake Phobos movement and decrease its orbit radius. This fact shows that $\mu < 0$ for Mars. It is necessary to underline the general idea that namely this force (6.4.3) is responsible for rotation in the Universe. Namely this force originates voluntary rotation of nonstabilized satellites and so on.

But why does not this acceleration untwist the celestial bodies up their rupture by centrifugal forces? The following fact helps' to answer this question. It is known that young stars do not have a high angular velocity of their own rotation. This grows in time, reaches its maximum for mature stars and decreases in a star's old age. That means that there exists a mechanism which periodically changes the sign of μ.

μ is mainly positive for young stars and negative for old ones. We speak here of middle magnitudes of μ because the sign evidently changes much more often than once in a star's life. The corroboration of it is periodical change of the Earth electromagnetic field polarity. It is known that the Earth's electromagnetic field is originated from streams in the Earth liquid nucleus. Two factors are not clear here: what is the energy source for this process and why are these streams directed against the Earth's rotation?

The proposed approach answers both above questions.

The source of the energy is the force (6.4.2) and the direction of the streams is defined by $\mu < 0$. In particular this means that the angular velocity of the Earth's own rotation is decreasing and linear correlation between it and μ fluctuations should be observed.

Let us find the ratio μ/Ma^3 for Mars in conclusion of the section.

Let M be Mars' mass, m be Phobos' mass, R be Phobos orbit radius, ΔR be change of radius per year, v be velocity and ω be angular velocity of Phobos.

Kinetic energy of Phobos

$$K=\frac{mv^2}{2},\ v^2=\frac{\gamma M}{2R}.$$

So,

$$K=\frac{\gamma mM}{2R}.$$

Kinetic energy increment

$$\Delta K=\frac{\gamma mM}{2}\left(\frac{1}{R}-\frac{1}{R-\Delta R}\right)=-\frac{\gamma mM\Delta R}{2R^2}. \tag{6.4.4}$$

This increment must be equal to the work of the force (6.4.3) per year

$$W=\frac{\gamma\mu m\omega^2 2\pi N}{a^2R}, \tag{6.4.5}$$

where N is the number of Phobos' revolutions per year. If (6.4.4) and (6.4.5) are equated supposing $\Delta R = 0.09$ m/year then

$$\frac{\mu}{Ma^2}=\frac{\Delta R}{4\pi NR\omega^2}\approx 5.7\times 10^{-6}\ \text{s}^2. \tag{6.4.6}$$

6.5. Perihelion Displacement, Red Shift, Ray Deviation in the Sun Gravimagnetic Field

Only forces connected with planet mechanic movement in gravimagnetic field of the Sun were taken into account in the previous chapter. The inner planetary gravicurrents were not considered. Let us investigate the force born by interaction of gravimagnetic fields of the Sun and planets.

According to (6.1.9) this force is

$$\mathbf{F}=\mathbf{J}\times\mathbf{B}, \tag{6.5.1}$$

where $\mathbf{J}$ is a planet's gravicurrent and $\mathbf{B}$ is the Sun gravimagnetic field.

In coordinate form

$$\begin{aligned}
F_1&=-J_2\frac{\gamma\mu}{a^2}\left(\frac{1}{r^3}-\frac{3x_3^2}{r^5}\right)-J_3\frac{\gamma\mu}{a^2}\frac{3x_2x_3}{r^5};\\
F_2&=+J_3\frac{\gamma\mu}{a^2}\frac{3x_1x_3}{r^5}-J_1\frac{\gamma\mu}{a^2}\left(\frac{1}{r^3}-\frac{3x_3^2}{r^5}\right);\\
F_0&=J_1\frac{\gamma\mu}{a^2}\frac{3x_2x_3}{r^5}-J_2\frac{\gamma\mu}{a^2}\frac{3x_1x_3}{r^5}.
\end{aligned} \tag{6.5.1a}$$

One has for the planet moving in (X_1X_2) plane ($x_3 = 0$)

$$\begin{aligned}
F_1&=-J_2\frac{\gamma\mu}{a^2r^3};\\
F_2&=+J_1\frac{\gamma\mu}{a^2r^3};\\
F_3&=0.
\end{aligned} \tag{6.5.2}$$

Taking into account that gravicurrent J moves together with the planet around the Sun one obtains

$$\begin{aligned}
J_1&=-J\frac{x_2}{r};\\
J_2&=-J\frac{x_1}{r}.
\end{aligned} \tag{6.5.3}$$

If to put (6.5.3) into (6.5.2), then

$$\begin{aligned}
F_1&=-J\frac{\gamma\mu}{a^2r^4}x_1;\\
F_2&=-J\frac{\gamma\mu}{a^2r^4}x_2;\\
F_3&=0.
\end{aligned} \tag{6.5.4}$$

In other words an additional radial force appears between the Sun and the planet moving in the Sun's equatorial plane because of interaction of their gravimagnetic fields. This force's magnitude is

$$F=-J\frac{\gamma\mu}{a^2r^3}. \tag{6.5.5}$$

Newton's principia already demonstrated that such a force originates perihelion displacement of planet's orbit. This displacement (radian per a revolution) is defined by the formula

$$\Delta\theta=\frac{2\pi Fr^3}{\gamma mMR_0(1-e^2)}=\frac{2\pi J\mu}{mMa^2R_0(1-e^2)}\ \text{rad/rev.} \tag{6.5.6}$$

Here M is the Sun's mass, m is planet mass, R_0 is big halfaxis and e is eccentricity of the platen's orbit.

Assumption 1

$$J=\alpha(t)ma,$$
$$\mu=\alpha(t)Mc^2,$$

where c is light velocity, and a is graviton acceleration, $\alpha(t)$ is time function, characterizing the tensity of gravimagnetic field in solar system.

By putting the supposed character of J and μ into (6.5.6) one gets

$$\Delta\theta = \frac{2\pi\alpha^2(t)c^2}{aR_0(1-e^2)} \text{ rad/rev}. \tag{6.5.6a}$$

Or

$$\frac{\alpha^2(t)c^2}{a} = \frac{\Delta\theta R_0(1-e^2)}{2\pi}. \tag{6.5.6b}$$

It is possible to find the left part of the equality using the data on today Merkurius perihelion displacement. One has

$$\frac{\alpha^2(t_0)c^2}{a} \approx 4.445\times10^5 \text{ m}. \tag{6.5.6c}$$

where t_0 is the moment of measurement.

The velocity of $\alpha(t)$ changing is proposed slow enough.

Let us return to (6.4.6) equality. Using the proposed character of μ one obtains

$$\frac{\alpha^2(t_0)c^2}{a^2} \approx 5.7\times10^{-6} \text{ s}^2. \tag{6.5.6d}$$

Eqs. (6.5.6) and (6.5.6*a*) give us the possibility to find constants

$$a = 7.796\times10^{10} \text{ m/s}^2,\ \alpha(t_0) = 0.621. \tag{6.5.6e}$$

For other planet:

Earth: $a = 10.12\times10^{10}$ m/s^2, $\alpha = 0.806$,

Venus: $a = 7.572\times10^{10}$ m/s^2, $\alpha = 0.603$,

Mars: $a = 6.33\times10^{10}$ m/s^2, $\alpha = 0.504$,

(1566) Icarus: $a = 7.577\times10^{10}$ m/s^2, $\alpha = 0.603$.

One could note a surprising similarity between (6.5.6) and especially (6.5.6*a*) and the corresponding formula of general relativity theory. Nevertheless this is true only for (X_1X_2) plane (the Sun's equator plane). It looks as follows for (X_1X_3) plane (the Sun's meridian plane):

$$J_1 = -J\frac{x_3}{r};$$
$$J_2 = +J\frac{x_1}{r}.$$

Let

$$\alpha = J\frac{\gamma\mu}{a^2}. \tag{6.5.7}$$

Then the force affecting the planet looks as follows

$$F_1 = 0,$$
$$F_2 = \frac{\alpha x_3}{r^4}\left(3\frac{x_1^2}{r^2} - 3\frac{x_3^2}{r^2} + 1\right),$$
$$F_3 = 0,$$

That means that the planet is affected only by lateral force F_2. For greater clearness let us use polar coordinates

$$x_1 = r\cos\theta,\ x_3 = r\sin\theta,$$
$$F_2 = \frac{\alpha\sin\theta}{r^3}(3\cos2\theta + 1).$$

and indicate the force magnitude in some points

$$F_2(\theta=0) = 0,\ F_2(\theta=\pi/4) = \frac{\alpha\sqrt{2}}{2r^3},$$
$$F_2(\theta=\pi/2) = -\frac{2\alpha}{r^3},\ F_2(\theta=3\pi/4) = \frac{\alpha\sqrt{2}}{2r^3},$$
$$F_2(\theta=\pi) = 0,\ F_2(\theta=5\pi/4) = -\frac{\alpha\sqrt{2}}{2r^3},$$
$$F_2(\theta=3\pi/2) = -\frac{4\alpha}{r^3},\ F_2(\theta=7\pi/4) = -\frac{\alpha\sqrt{2}}{2r^3}.$$

One could say that a planet's orbit is affected by a moment of force pressing it to the Sun's equatorial plane (in the way a frame with electric current is revolved in an electromagnetic field). It is natural to suppose that namely this force is responsible for the fact that natural satellites' orbits are close to equatorial planes of central bodies.

Let us consider photon's motion to an observer on the Earth from equatorial (X_1X_2) plane and polar (X_1X_3) plane edges of the Sun. Let the axes (X_1X_2) be disposed so that x_1 is directed to the observer on the Earth. The gravicurrent in straight centrifugal movement looks as follows:

$$J_1 = J\frac{x_1}{r};$$
$$J_2 = J\frac{x_2}{r}; \tag{6.5.8}$$
$$J_3 = J\frac{x_3}{r}.$$

The force (6.5.1*a*) in (X_1X_2) plane (X_3 = 0, J_3 = 0) looks as below

$$F_1 = -J_2\frac{\gamma\mu}{a^2r^3} = -\alpha\frac{x_2}{r^4};$$
$$F_2 = +J_1\frac{\gamma\mu}{a^2r^3} = +\alpha\frac{x_1}{r^4}; \tag{6.5.9}$$
$$F_3 = 0,$$

and in (X_1X_3) plane (X_2 = 0, J_2 = 0)

$$F_1 = 0;$$
$$F_2 = \alpha\frac{x_1}{r^4}; \tag{6.5.10}$$
$$F_3 = 0.$$

Let r_0 be the Sun's radius, R_0 be the distance from the Sun to the Earth. F_1 performs over photon certain work. This work for equatorial photon ($x_2 = r_0$) is:

$$A = \int_0^{R_0} F_1 dx_1 = -\alpha\int_0^{R_0}\frac{r_0 dx_1}{r^4} =$$
$$= -\frac{\alpha}{r_0}\left(\int_0^{R_0}\frac{(r_0^2+x_1^2)dx_1}{(x_1^2+r_0^2)^2} - \int_0^{R_0}\frac{x_1 dx_1}{(x_1^2+r_0^2)^2}\right) = \tag{6.5.11}$$
$$= -\frac{\alpha}{2r_0}\left(\frac{\operatorname{arctg}(R_0/r_0)}{r_0} + \frac{R_0}{R_0^2+r_0^2}\right)\xrightarrow[R_0\to\infty]{} -\frac{\pi\alpha}{4r_0^2}.$$

If $\alpha > 0$, *i.e.*, J and μ are of the same sign (this condition is valid for sure if the Sun directs photon gravimagnetic field along its force lines), then the work (6.5.11) is negative and originates red displacement in ray spectrum, $\alpha < 0$ originates blue displacement.

The dislacement for a polar photon is absent because of the first equality of system (6.5.10).

Projections F_2 and F_3 also perform work deviating the ray. (6.5.9) and (6.5.10) mean that displacement along x_3 is absent either for equatorial or for polar rays. Equal deviations for both of them take place along x_2 coordinate.

Let m be photon mass. Then its deviation along x_2 coordinate is

$$s(t_0) = \frac{\alpha}{m}\int_0^{t_0}\int_0^{\tau} F_2 d\tau dt,$$

where t_0 is time of photon moving from the Sun to the observer.

$$t = \frac{x_1}{c},$$

where c is light velocity.

$$s(R_0) = \frac{\alpha}{mc^2}\int_0^{R_0}\int_0^{x_1} \frac{x_1 dx_1 dx_1}{(x_1^2 + r_0^2)^2} = -\frac{\alpha \,\mathrm{arctg}(R_0/r_0)}{2mc^2 r_0} \xrightarrow[R_0\to\infty]{} -\frac{\pi\alpha}{4mc^2 r_0}. \tag{6.5.12}$$

Let us find numerical evaluations for ray deviation using correlation (6.5.6*c*)

$$s = -\frac{\pi\gamma M C_1 C_2}{4c^2 r_0 a^2} \approx 8\times 10^{-3}\ \mathrm{m}.$$

Here M is the Sun's mass.

Just in the same way energy of red displacement

$$A = \frac{\pi\gamma\mu J}{4r_0^2} = \frac{\pi\gamma\hbar\nu M}{4c^2 r_0^2}\cdot\frac{C_1 C_2}{a^2} \approx 1\times 10^{-33}\ \frac{\mathrm{kg}\cdot\mathrm{m}^2}{\mathrm{s}^2}.$$

Relative decreasing of frequency is

$$\frac{\Delta\nu}{\nu} = 10^{-10}.$$

It is essentially less than red displacement because of Newton's potential. It is easy counted

$$\frac{\Delta\nu}{\nu} = 2\times 10^{-6}.$$

To conclude the paragraph let us show modern deduction of formula (6.5.6). The appearance of additional force (6.5.5) makes the differential vector equation of planet movement as follows:

$$\frac{d^2 r}{dt^2} + L\frac{r}{r^3} = 0,$$

where $L = \left(1 + \frac{J\mu}{Mma^2 r}\right)$, M is central body mass, m is planet mass. Let $\beta = -\frac{J\mu}{Mma^2}$. Then the functional equation of planet movement is

$$r = \frac{\sigma^2 - \gamma M\beta}{\gamma M + \lambda\cos\theta},$$

where σ is magnitude of constant square, λ is magnitude of Laplace vector, θ is angle. Let

$$p = \frac{\sigma}{\gamma M},\ e = \frac{\lambda}{\gamma M}.$$

then

$$r = \frac{p}{1 + e\cos\theta} - \frac{\beta}{1 + e\cos\theta}.$$

or

$$\frac{\beta}{p} = 1 - \frac{r(1 + e\cos\theta)}{p}.$$

One gets integrating over θ from 0 to 2π

$$2\pi - \frac{\int_0^{2\pi} r d\theta}{p} = \frac{2\pi\beta}{p}.$$

The left part of the equality is the angle of planet's orbit rotation as a unit per one revolution. Let us designate it $\Delta\theta$. The focal parameter $p = R_0(1 - e^2)$.

One gets in the end:

$$\Delta\theta = \frac{2\pi J\mu}{a^2 mMR_0(1 - e^2)}.$$

6.6. Analogies between Gravitational and Electric Fields

Let us consider a homogeneous equation of the kind (6.1.1) and (6.1.2)

$$\nabla\cdot\nabla\varphi - \frac{1}{a^2}\frac{\partial^4\varphi}{\partial t^4} = 0. \tag{6.6.1) (6.1}$$

This describes the spreading of the waves of gravity in empty space.

Theorem 1. Gravifields **G** and **D** in empty space satisfy (6.6.1).

The proof results directly from the definition of **G** and **D** by means of **A** and φ.

If one takes rotor of homogeneous equation (6.1.1), then one gets

$$\nabla\cdot\nabla\mathbf{D} - \frac{1}{a^2}\frac{\partial^4\mathbf{D}}{\partial t^4} = 0. \tag{6.6.2}$$

One gets the same equation for **G** in the following way. Let us take rotor of both parts of the equation (6.1.5)

$$\nabla\times(\nabla\times\mathbf{G}) = -\frac{\partial^2}{\partial t^2}(\nabla\times\mathbf{D}).$$

But

$$\nabla\times(\nabla\times\mathbf{G})=\nabla(\nabla\cdot\mathbf{G})-\nabla\cdot(\nabla\mathbf{G}).$$

In empty space

$$\frac{d\mathbf{R}}{dt}=A(\mathbf{v})=B(\mathbf{v})+2C(\mathbf{v}).$$

Taking into account the absence of gravicurrents and differentiating (6.1.7) one gets the following:

$$\frac{\partial^2\mathbf{G}}{\partial t^2}(\nabla\times\mathbf{D})=-\frac{1}{a^2}\frac{\partial^4\mathbf{G}}{\partial t^4},$$

i.e.,

$$\nabla\cdot\nabla\mathbf{G}=\frac{1}{a^2}\frac{\partial^4\mathbf{G}}{\partial t^4}.$$

Let Γ be an arbitrary contour, S be a surface drawn on it, n be a normal to it.

The following theorem is true.

Theorem 2

$$\int_\Gamma \mathbf{G}d\mathbf{l}=-\frac{\partial^2}{\partial t^2}\int_S \mathbf{D}\cdot\mathbf{n}ds. \tag{6.6.3}$$

The assertion results from (6.1.5) and Stocks' theorem. Theorem 2 is gravianalogue of Faraday law. The left part of may be called a gravimoving force and the right part under symbol of differention is a gravimagnetic flow.

6.7. Boundary Problem for Potentials

Let us consider boundary and Couchy problems for homogenious equation of (6.1.1) type

$$\nabla\cdot\nabla u-\frac{1}{a^2}\frac{\partial^4 u}{\partial t^4}=0; \tag{6.7.1}$$

$$\begin{aligned} &u\Big|_{t=0}=u_0(x), \quad \frac{\partial u}{\partial t}\Big|_{t=0}=u_1(x),\\ &\frac{\partial^2 u}{\partial t^2}=u_2(x), \quad \frac{\partial^3 u}{\partial t^3}\Big|_{t=0}=u_3(x); \end{aligned} \tag{6.7.2}$$

$$\alpha u=\beta\frac{\partial u}{\partial n}\Big|_S=0,\ t\ge 0, \tag{6.7.3}$$

$x\in\mathbf{G}$, $\mathbf{G}\subset R^3$ is a region in three-dimensional Euclidian space, where the process takes place, S is it's piecewise boundary, $\alpha\in C(s)$, $\beta\in C(s)$, $\alpha(x)\ge 0$, $\beta(x)\ge 0$, $\alpha(x)+\beta(x)>0$, $x\in S$.

We shall find the solution by Fourier method as a product

$$T(t)\cdot X(x), \tag{6.7.4}$$

satisfying boundary conditions (6.7.3). After that a linear combination of these solutions satisfying initial conditions (6.7.2) will be constructed. Substituting (6.7.4) into (6.7.1) one obtains

$$\frac{T''''(t)}{a^2T(t)}=\frac{MX(x)}{X(x)}, \tag{6.7.5}$$

where operator M is defined by the equality

$$MX(x)=\nabla\cdot\nabla X(x).$$

One obtains two equalities from (6.7.5)

$$MX=\lambda x, \tag{6.7.6}$$

$$T''''(t)=\lambda a^2 T,\ \lambda=\text{const}. \tag{6.7.7}$$

Solution $X(x)$ of (6.7.6) must satisfy boundary conditions, therefore eigen functions X_j and eigen values λ_j can be taken as X and λ.

It is known that $\lambda_j>0$, eigen functions X_j can be taken real and orthonormal. Any function $f\in C^2(G)\cap C^1(G)$, $Mf\in L_2(\bar{G})$, $f/S=0$ can be decomposed in Fourier series of own functions X_j.

Let $\lambda=k^2$, к is real because $\lambda>0$. General real solution of is as follows:

$$\begin{aligned} &T_j(t)=b_j\cos\sqrt{k_j a t}+C_j\sin\sqrt{k_j a t}+\\ &+d_j\operatorname{ch}\sqrt{k_j a t}+l_j\operatorname{sh}\sqrt{k_j a t},\\ &b_j,\ C_j,\ d_j,\ l_j=\text{const}. \end{aligned} \tag{6.7.8}$$

Thus a countable number of partial (linearly independent) solutions of (6.7.1) equation are constructed:

$$\begin{aligned} &T_j(t)X_j(x)=(b_j\cos\sqrt{k_j a t}+C_j\sin\sqrt{k_j a t}+\\ &+d_j\operatorname{ch}\sqrt{k_j a t}+l_j\operatorname{sh}\sqrt{k_j a t})X_j, \end{aligned} \tag{6.7.9}$$

They satisfy boundary conditions (6.7.3) and contain voluntary constants b_j, C_j, d_j, l_j. Let us construct a formal row:

$$\begin{aligned} \sum_{j=1}^{\infty}T_j(t)X_j(x)=\sum_{j=1}^{\infty}(&b_j\cos t\sqrt{k_j a}+C_j\sin t\sqrt{k_j a}+\\ &+d_j\operatorname{ch} t\sqrt{k_j a}+l_j\operatorname{sh} t\sqrt{k_j a})X_j. \end{aligned} \tag{6.7.10}$$

Coefficients b_j, C_j, d_j, l_j are picked up in the way to satisfy initial conditions (6.7.2)

$$\sum_{j=1}^{\infty}\frac{b_j+d_j}{2}X_j=u_0(x),\quad \sum_{j=1}^{\infty}\sqrt{k_j a}\frac{C_j+l_j}{2}X_j=u_1(x).$$

$$\sum_{j=1}^{\infty}k_j a\frac{b_j-d_j}{2}X_j=-u_2(x),\quad \sum_{j=1}^{\infty}(k_j a)^{3/2}\frac{C_j-l_j}{2}X_j=-u_3(x).$$

The orthonormal system $\{X_j\}$ is full in $L_2(G)$, therefore

$$\begin{aligned} &\frac{b_j+d_j}{2}=\int_G u_0X_jdx,\\ &\frac{C_j+l_j}{2}=\int_G u_1X_jdx\cdot\frac{1}{\sqrt{k_j a}},\\ &\frac{b_j-d_j}{2}=-\frac{1}{k_j a}\int_G u_2X_jdx,\\ &\frac{C_j-l_j}{2}=-\frac{1}{(k_j a)^{3/2}}\int_G u_3X_jdx. \end{aligned} \tag{6.7.11}$$

That is

$$
\begin{aligned}
b_j &= \frac{1}{2}\int_G \left(u_0 - \frac{1}{k_j a} u_2 \right) X_j dx, \\
c_j &= \frac{1}{2\sqrt{k_j a}} \int_G \left(u_1 - \frac{1}{k_j a} u_3 \right) X_j dx, \\
d_j &= \frac{1}{2}\int_G \left(u_0 + \frac{1}{k_j a} u_2 \right) X_j dx, \\
l_j &= \frac{1}{2\sqrt{k_j a}} \int_G \left(u_1 + \frac{1}{k_j a} u_3 \right) X_j dx.
\end{aligned}
\tag{6.7.12}
$$

Let us now consider a nonhomogeneous equation:

$$
\frac{1}{a_2}\frac{\partial^4 u}{\partial t^4} = Mu + F(x,t). \tag{6.7.13}
$$

For any $t > 0$ let us decompose the solution of the problem, (6.7.2), (6.7.3) into Fourier series over eigen functions $\{X_j\}$ of the operator M.

$$
u(x,t) = \sum_{j=1}^{\infty} T_j(t) X_j(x), \quad T_j(t) = \int_G u X_j dx. \tag{6.7.14}
$$

The initial conditions

$$
\begin{aligned}
T_j(0) &= b_j + d_j = \int_G u_0(x) X_j dx, \\
T_j'(0) &= C_j + l_j = \frac{1}{\sqrt{k_j a}} \int_G u_1 X_j dx, \\
T_j''(0) &= b_j - d_j = -\frac{1}{k_j a} \int_G u_2 X_j dx, \\
T_j'''(0) &= C_j - l_j = -\frac{1}{(k_j a)^{3/2}} \int_G u_3 X_j dx.
\end{aligned}
\tag{6.7.15}
$$

Or

$$
\begin{aligned}
b_j &= \frac{1}{2}\int_G \left(u_0 - \frac{1}{k_j a} u_2 \right) X_j dx, \\
C_j &= \frac{1}{2(k_j a)^{1/2}} \int_G \left(u_1 - \frac{1}{k_j a} u_3 \right) X_j dx, \\
d_j &= \frac{1}{2}\int_G \left(u_0 + \frac{1}{k_j a} u_2 \right) X_j dx, \\
l_j &= \frac{1}{2(k_j a)^{1/2}} \int_G \left(u_1 + \frac{1}{k_j a} u_3 \right) X_j dx.
\end{aligned}
\tag{6.7.15a}
$$

Because of (6.7.2), (6.7.14) and (6.7.11) the unknown functions must satisfy the initial conditions (6.7.15*a*). Let us construct differential equation for functions $T_j(t)$. One gets the chain of equalities scalarly producting (6.7.13) on X_j

$$
\frac{1}{a^2}\int_G \frac{\partial^4 u}{\partial t^4} X_j dx = \frac{1}{a^2}\frac{d^4}{dt^4}\int_G u X_j dx = \int_G M u X_j dx + \int_G F X_j dx = \int_G u M X_j dx + \int_G F X_j dx = k^2 \int_G u X_j dx + \int_G F X_j dx,
$$

Thus because of (6.7.14) functions T_j satisfy the equation

$$
T_j - k^2 a^2 T_j = a^2 h_j(t), \tag{6.7.16}
$$

where

$$
h_j(t) = \int_G F(x,t) X_j(x) dx. \tag{6.7.17}
$$

One obtains solving Couchy problem for (6.7.16) with initial conditions (6.7.15*a*):

$$
\begin{aligned}
T_j(t) = \int_G \Bigg[& \frac{a^2}{2(k_j a)^{3/2}} \left(\int_0^t \left(\operatorname{sh}\sqrt{k_j a}(t-\tau) - \sin\sqrt{k_j a}(t-\tau) \right) \right) F(x,\tau) d\tau + u_0 \left(\cos\sqrt{k_j a} t + \operatorname{ch}\sqrt{k_j a} t \right) - \\
& - \frac{u_1}{\sqrt{k_j a}} \left(\sin\sqrt{k_j a} t + \operatorname{sh}\sqrt{k_j a} t \right) - \frac{u_2}{k_j a} \left(\cos\sqrt{k_j a} t - \operatorname{ch}\sqrt{k_j a} t \right) - \frac{u_3}{(k_j a)^{3/2}} \left(\sin\sqrt{k_j a} t - \operatorname{sh}\sqrt{k_j a} t \right) \Bigg] dx = \\
= & \frac{a^2}{2(k_j a)^{3/2}} \int_0^t \left(\operatorname{sh}\sqrt{k_j a}(t-\tau) - \sin\sqrt{k_j a}(t-\tau) \right) h_j d\tau + b_j \cos\sqrt{k_j a} t + C_j \sin\sqrt{k_j a} t + d_j \operatorname{ch}\sqrt{k_j a} t + l_j \operatorname{sh}\sqrt{k_j a} t.
\end{aligned}
\tag{6.7.18}
$$

Substituting (6.7.18) into (6.7.14) one obtains formal solution of the mixed problem (6.7.13), (6.7.2), (6.7.3)

$$
\begin{aligned}
u(x,t) = \sum_{j=1}^{\infty} T_j(t) X_j(x) = \sum_{j=1}^{\infty} \Bigg(& \frac{a^2}{2(k_j a)^{3/2}} \cdot \int_0^t \left(\operatorname{sh}\sqrt{k_j a}(t-\tau) - \sin\sqrt{k_j a}(t-\tau) \right) h_j d\tau + b_j \cos\sqrt{k_j a} t + \\
& + C_j \sin\sqrt{k_j a} t + d_j \operatorname{ch}\sqrt{k_j a} t + l_j \operatorname{sh}\sqrt{k_j a} t \Bigg) X_j(x).
\end{aligned}
\tag{6.7.19}
$$

6.8. Rotation on Circumference. Dependence on Space Coordinates

Let a mass m distributed with density ρ rotates with constant angular velocity ω on a circumference of radius r_0 disposed in (X_1X_2) plane with the center in coordinates' origin. Such a rotation originates a gravicurrent

$$J=-mr_0\omega^2$$

with density

$$j=\rho r_0\omega^2.$$

Vector gravipotential **A** will satisfy the equations

$$\nabla\cdot\nabla A_1-\frac{1}{a^2}\frac{\partial^4 A_1}{\partial t^4}=-\frac{4\pi\gamma}{a^2}\rho r_0\omega^2\cos\omega t, \tag{6.8.1}$$

$$\nabla\cdot\nabla A_2-\frac{1}{a^2}\frac{\partial^4 A_2}{\partial t^4}=-\frac{4\pi\gamma}{a^2}\rho r_0\omega^2\sin\omega t, \tag{6.8.2}$$

$$\nabla\cdot\nabla A_3-\frac{1}{a^2}\frac{\partial^4 A_3}{\partial t^4}=0. \tag{6.8.3}$$

A is a function only of two arguments: time t and distance from the origin of coordinates.

Let

$$\alpha=\frac{\gamma}{a^2}. \tag{6.8.4}$$

Let us solve the problem with the following initial conditions

$$\begin{aligned}
&T_1(0)=\alpha m_0\omega^2,\ T_1'(0)=0,\\
&T_1''(0)=-\alpha m_0\omega^4,\ T_1'''(0)=0;\\
&T_2(0)=0,\ T_2'(0)=\alpha m_0\omega^3,\\
&T_2''(0)=0,\ T_2'''(0)=-\alpha m_0\omega^5;\\
&T_2(0)=0,\ T_2'(0)=0,\\
&T_2''(0)=0,\ T_2'''(0)=0.
\end{aligned} \tag{6.8.5}$$

Let boundary conditions be:

$$\begin{aligned}
&X_j(0)=k_jr_0.\\
&X_j(r_0)=\mathrm{sh}(k_jr_0),\ j=1,2,\ldots.
\end{aligned} \tag{6.8.6}$$

The fundamental solution is

$$C_j^1\,\mathrm{ch}(k_jr);\ C_j^2\,\mathrm{sh}(k_jr),\ j=1,2,3,\ldots. \tag{6.8.7}$$

Let the condition of resonance be valid: there exist such k_j^* that

$$\omega=\sqrt{k_j^*a}. \tag{6.8.8}$$

This k_j^* is designated by k. For this k the constant in inner Dirichlet problem is

$$C_1^1=0;\ C_1^2=r_0.$$

Thus

$$X(r)=\frac{r_0\,\mathrm{sh}(kr)}{r},\ r=[0,r_0].$$

Vector potential in this case is

$$A_1(x,t)=\frac{\gamma}{a^2}\left[\frac{2\pi\rho a^2r_0}{\omega}\int_0^t(\sin\omega(t-\tau)-\mathrm{sh}\,\omega(t-\tau))\cos\omega\tau d\tau+\right.$$
$$\left.+\ m_0\omega^2\cos\omega t-m_0\omega^2\,\mathrm{ch}\,\omega t\right]\frac{r_0\,\mathrm{sh}(kr)}{r}, \tag{6.8.9}$$

$$A_2(x,t)=\frac{\gamma}{a^2}\left[\frac{2\pi\rho a^2r_0}{\omega}\int_0^t(\sin\omega(t-\tau)-\mathrm{sh}\,\omega(t-\tau))\sin\omega\tau d\tau+\right.$$
$$\left.+\ m_0\omega^2\sin\omega t-m_0\omega^2\,\mathrm{sh}\,\omega t\right]\frac{r_0\,\mathrm{ch}(kr)}{r}. \tag{6.8.10}$$

The expressions in square brackets in (6.8.9) and (6.8.10) depend only on t and has a dimension kg/s.

It is natural to consider them as components of gravicurrent force

$$\mathbf{J}=(J_1,J_2,0),$$

$$J_1(t)=\frac{2\pi\rho a^2r_0}{\omega}\int_0^t(\sin\omega(t-\tau)-\mathrm{sh}\,\omega(t-\tau))\cos\omega\tau d\tau+$$
$$+\,m_0\omega^2\cos\omega t-m_0\omega^2\,\mathrm{ch}\,\omega t, \tag{6.8.11}$$

$$J_2(t)=\frac{2\pi\rho a^2r_0}{\omega}\int_0^t(\sin\omega(t-\tau)-\mathrm{sh}\,\omega(t-\tau))\sin\omega\tau d\tau+$$
$$+\,m_0\omega^2\sin\omega t-m_0\omega^2\,\mathrm{sh}\,\omega t. \tag{6.8.12}$$

One gets for outer Dirichlet problem:

$$\begin{aligned}
&C_1\,\mathrm{ch}(kr_0)+C_2\,\mathrm{sh}(kr_0)=\mathrm{sh}(kr_0),\\
&C_1\,\mathrm{ch}(\infty)+C_2\,\mathrm{sh}(\infty)=0.
\end{aligned} \tag{6.8.13}$$

Or

$$C_1=-C_2=r_0\exp\{kr_0\}\mathrm{sh}(kr_0),$$
$$X(r)=\frac{r_0\exp\{k(r_0-r)\}\mathrm{sh}(kr_0)}{r},\ \ r\geq r_0. \tag{6.8.14}$$

And vector gravipotential is

$$A_1=\alpha J_1\frac{r_0\exp\{k(r_0-r)\}\mathrm{sh}(kr_0)}{r},\ \ r\geq r_0; \tag{6.8.15}$$

$$A_2=\alpha J_2\frac{r_0\exp\{k(r_0-r)\}\mathrm{sh}(kr_0)}{r},\ \ r\geq r_0. \tag{6.8.16}$$

Eqs. (6.8.15) and (6.8.16) involves that this potential exponentially decreases and is essential only in the vicinity of r_0. Nevertheless, this potential is not unique in outer space. The potential induced by the inner area of the circle is added to it. One can find it integrating $\frac{r_0\,\mathrm{sh}(kr_0)}{r}$ over area of the circle.

One gets in polar coordinates

$$v=r_0\int_0^{2\pi}d\theta\int_0^{r_0}\mathrm{sh}(kr)dr=\frac{2\pi r_0}{k}(\mathrm{ch}(kr_0)-1).$$

Let us investigate v as a function of k, taking into account that resonance conditions (6.8.8) mean

$$k=\frac{\omega^2}{a}. \tag{6.8.17}$$

When k is small one gets decomposing $\mathrm{ch}(kr)$ into row

Thus v is analogue of square loop with electric current. When $k\in[0,\,r_0^{-1}]$, v linearly grows from zero to πr_0^2. After that exponential growth of v begins.

The expression $\boldsymbol{\mu}=\mathbf{J}v$ is natural to call gravimagnetic dipole moment. The vector gravipotential of dipole is

$$\mathbf{D}=\frac{4\pi\gamma}{a^2}\mu.$$

It originates potential

$$\mathbf{A}=\frac{\gamma}{a^2R^2}\mu. \tag{6.8.18}$$

in the points of sphere of radius $R\gg r_0$.

Eq. (6.8.18) defines $\mathbf{A}$ by means of $\mathbf{I}$ projections. For greater similarity with the modern tradition the direction of $\mathbf{I}$ may be defined as a normal to plane of the loop with positive direction defined according to right hand rule. If so (6.8.18) coincides with

$$\mathbf{A}=\frac{\gamma}{a^2R^2}\mu\times\mathbf{R},\ R>r_0, \tag{6.8.19}$$

This formula was supposed earlier as analogue of the electric field.

One can get scalar potential using gauge condition (6.1.3). One gets for the inner Dirichlet problem:

$$\nabla\cdot A=\frac{\gamma r_0\,\mathrm{ch}(kr)}{a^2r^2}(J_1x_1+J_2x_2)\left(k-\frac{1}{r}\right).$$

Let

$$m_1(t)=\int_0^t\int_0^\tau J_1dsd\tau,$$
$$m_2(t)=\int_0^t\int_0^\tau J_2dsd\tau,$$
$$\mathbf{M}(t)=(m_1,m_2,0).$$

This vector will be called a dynamic mass. Condition (6.1.3) gives us the scalar potential in inner area of the circle

$$\varphi=\frac{\gamma r_0\,\mathrm{ch}(kr)}{r^2}\left(\frac{1}{r}-k\right)(m_1x_1+m_2x_2)+\varphi'(0)t+\varphi(0). \tag{6.8.20}$$

Here $\varphi(0)$ is static Newtonian potential, and $\varphi'(0)=0$ because there is no change of potential in the initial moment.

Now (6.1.3*a*) gives us the possibility to find a gravifield in the inner area of the circle.

$$-\frac{d\varphi}{dx_1}=\frac{\gamma r_0\,\mathrm{sh}(kr)}{r^2}\left[\left(\frac{3}{r}-3k\right)m_1-\right.$$
$$\left.-\frac{1}{r}\left(k^2-\frac{3k}{r}+\frac{3}{r^2}\right)(m_1x_1+m_2x_2)x_1\right]-\frac{\partial\varphi(0)}{\partial x_1},$$
$$-\frac{d\varphi}{dx_2}=\frac{\gamma r_0\,\mathrm{sh}(kr)}{r^2}\left[\left(\frac{3}{r}-3k\right)m_2-\right.$$
$$\left.-\frac{1}{r}\left(k^2-\frac{3k}{r}+\frac{3}{r^2}\right)(m_1x_1+m_2x_2)x_2\right]-\frac{\partial\varphi(0)}{\partial x_2}.$$

Let

$$p_1=\frac{\partial^2J_1}{\partial t^2},\ \ p_2=\frac{\partial^2J_2}{\partial t^2}.$$

Thus

$$-\frac{\partial^2\mathbf{A}}{\partial t^2}=-\frac{\gamma r_0\,\mathrm{sh}(kr)}{ra^2}\mathbf{p}.$$

And finally, tensity of gravifield in inner area of the circle in vector form is

$$\mathbf{E}_{int}=-\frac{\gamma r_0\,\mathrm{sh}(kr)}{r}\left[\left(k^2-\frac{3k}{r}+\frac{3}{r^2}\right)\frac{(\mathbf{m}\cdot\mathbf{r})}{r^2}+\right.$$
$$\left.+\frac{\mathbf{p}}{a^2}+\left(\frac{3k}{r}-\frac{3}{r^2}\right)\mathbf{m}\right]-\nabla\varphi(0),\ \ r\in[0,\,r_0). \tag{6.8.21}$$

The solution of outer Dirichlet problem gives the following field for external area of the circle:

$$\mathbf{E}_{out}=-\frac{\gamma r_0\,\mathrm{sh}(kr_0)\exp\{k(r_0-r)\}}{r}\left[\left(k^2-\frac{3k}{r}+\frac{3}{r^2}\right)\frac{(\mathbf{m}\cdot\mathbf{r})}{r^2}+\right.$$
$$\left.+\frac{\mathbf{p}}{a^2}+\left(\frac{k}{r}-\frac{1}{r^2}\right)\mathbf{m}\right]-\nabla\varphi(0),\ \ r\in[r_0,\,\infty). \tag{6.8.22}$$

6.9. Rotation on Circumference. Dependence on Time

In order to clear up the physical essence of the correlations we got let us find $m(t)$, $\mathbf{J}(t)$, $\mathbf{p}(t)$ as evident functions of time.

$$\int_0^t (\sin\omega(t-\tau)-\operatorname{sh}\omega(t-\tau))\cos\omega\tau d\tau = \frac{1}{2}\left(t\sin\omega t - \frac{\operatorname{ch}\omega t}{\omega}\right);$$

$$\int_0^t (\sin\omega(t-\tau)-\operatorname{sh}\omega(t-\tau))\sin\omega\tau d\tau = \frac{1}{2}\left(t\cos\omega t - \frac{\operatorname{sh}\omega t}{\omega}\right).$$

Thus

$$J_1 = +\frac{\pi\rho r_0 a^2}{\omega}\left(t\sin\omega t - \frac{\operatorname{ch}\omega t}{\omega}\right) + m_0\omega^2(\cos\omega t + \operatorname{ch}\omega t), \quad (6.9.1)$$

$$J_2 = +\frac{\pi\rho r_0 a^2}{\omega}\left(t\cos\omega t - \frac{\operatorname{sh}\omega t}{\omega}\right) + m_0\omega^2(\sin\omega t + \operatorname{sh}\omega t). \quad (6.9.2)$$

From here with the accuracy of constants of integration which were taken account in the expression of scalar potential

$$m_1 = \pi\rho r_0 a^2\left(\frac{t\sin\omega t}{\omega^3} + \frac{\operatorname{ch}\omega t}{\omega^4} - \frac{2\cos\omega t}{\omega^4}\right) + m_0(-\cos\omega t + \operatorname{ch}\omega t), \quad (6.9.3)$$

$$m_2 = \pi\rho r_0 a^2\left(\frac{t\cos\omega t}{\omega^3} + \frac{\operatorname{sh}\omega t}{\omega^4} - \frac{2\sin\omega t}{\omega^4}\right) + m_0(-\sin\omega t + \operatorname{sh}\omega t), \quad (6.9.4)$$

$$p_1 = -\pi\rho r_0 a^2\left(\omega t\sin\omega t + \operatorname{ch}\omega t - 2\cos\omega t\right) + m_0\omega^4(-\cos\omega t + \operatorname{ch}\omega t), \quad (6.9.5)$$

$$p_2 = -\pi\rho r_0 a^2\left(\omega t\cos\omega t + \operatorname{sh}\omega t - 2\sin\omega t\right) + m_0\omega^4(-\sin\omega t + \operatorname{sh}\omega t). \quad (6.9.6)$$

If

$$m_0 = \frac{\pi\rho r_0 a^2}{\omega^4},$$

then one gets (taking into account (6.8.17))

$$m_1 = \frac{\pi\rho r_0}{k^2}(\cos\omega t + \omega t\sin\omega t), \quad (6.9.3a)$$

$$m_2 = \frac{\pi\rho r_0}{k^2}(\sin\omega t + \omega t\cos\omega t), \quad (6.9.4a)$$

$$p_1 = -\pi\rho r_0 a^2(\cos\omega t + \omega t\sin\omega t), \quad (6.9.5a)$$

$$p_2 = -\pi\rho r_0 a^2(\sin\omega t + \omega t\cos\omega t). \quad (6.9.6a)$$

Let us return to (6.8.21). Taking into account (6.9.3*a*)–(6.9.6*a*) one gets

$$\mathbf{E}^1_{int} = -\frac{\gamma r_0\operatorname{sh}(kr)}{r}\left[\left(k^2 - \frac{3k}{r} + \frac{3}{r^2}\right)\left(\frac{(\mathbf{m}\cdot\mathbf{r})}{r^2}x_1 - m_1\right) - 2\pi\rho r_0\cos\omega t\right] - \frac{\partial\varphi(0)}{\partial x_1}, \quad (6.9.7)$$

$$\mathbf{E}^2_{int} = -\frac{\gamma r_0\operatorname{sh}(kr)}{r}\left[\left(k^2 - \frac{3k}{r} + \frac{3}{r^2}\right)\left(\frac{(\mathbf{m}\cdot\mathbf{r})}{r^2}x_1 - m_1\right) - 2\pi\rho r_0\sin\omega t\right] - \frac{\partial\varphi(0)}{\partial x_2}. \quad (6.9.8)$$

when $k \to 0$, $E_{int} \to \nabla\varphi(0)$, *i.e.*, when rotation stops dynamic part of the force grows zero and only the Newtonian field preserves.

When $r \to 0$

$$E_{int}(r=0) = -2\pi\gamma\rho k r_0^2 - \nabla\varphi(0).$$

E_{int} in other points of the circle is a sum of two standing waves. Field in one these waves is directed along radius. Therefore, in order to keep a rotating mass on the circumference an additional force is necessary. This force as it was noted above, grows slowly when k is small. But when $k > 1/r_0$ it begins growing exponentially.

It is necessary to pin point now some difficulties in the results we achieved.

Correlations (6.9.3*a*) and (6.9.4*a*) forecast linear on t growth of dynamic mass because of resonance. That means that either there exists in nature a kind of «friction» which stops this growth or nature evades resonance in some way.

Let us write down for comparison the formula of gravicurrent force in nonresonance case $\omega^2 \neq ka$.

$$J_1 = 2\pi\rho r_0 a^2\left(\frac{\cos\sqrt{ka}t}{\omega^2 - ka} - \frac{\sqrt{ka}\left(\sqrt{ka}+\omega\right)}{\omega^4 - (ka)^2}\cos\omega t + \frac{\sqrt{ka}\operatorname{ch}\sqrt{ka}t}{(ka-\omega^2)\omega}\right), \quad (6.9.1a)$$

$$J_2 = 2\pi\rho r_0 a^2\left(\frac{\sin\sqrt{ka}t}{\omega^2 - ka} - \frac{\sqrt{ka}\left(\sqrt{ka}+\omega\right)}{\omega^4 - (ka)^2}\sin\omega t + \frac{\sqrt{ka}\operatorname{sh}\sqrt{ka}t}{(ka-\omega^2)\omega}\right). \quad (6.9.2a)$$

It is essential that exponential members in hyperbolic functions appear in formulae (6.9.1) and (6.9.2).

In our example it appeared to be possible to annihilate them by means of initial data. But if it is not possible it becomes a very serious problem. It has been mentioned above that processes in the Universe accessible for observation are periodic. This means that for these processes either exponential components are mutually annihilated or it is necessary for us to revise our habitaul ideas on mass and time.

Paragraphs 8 and 9 are illustrative. Only the resonance component is investigated in them. In general one should add the whole row (6.7.18) to this component. Such an investigation would be interesting if one knew the boundary data for atom nuclei or solar system. These boundary data are not known, therefore, it is useful to pin point some corrolaries of formulae (6.8.21), especially (6.8.22) in a qualitative way.

We saw that the rotation of mass induces standing waves of acceleration in outer space. It is natural to suppose that Bohr's orbits of electrons in atom corresponds to the surfaces of zero acceleration. So although electron rotates around nucleus it is not accelerated and therefore does not radiate. The radii of such surfaces are defined by own values:

$$r_n = 1/k_n,\ n = 1,2,3,\dots\ .$$

Some peculiarities of planet formation in solar system also become clear. The planets which satisfy Bodes' law and whose orbits are in close planes were born in close boundary conditions on the surfaces of zero acceleration, just like electrons' orbits. The conditions of Pluto's origin essentially differed from that of other planets. Mercury whose orbit lies almost precisely in the plane of the Sun's equator was possibly the last planet to be formed. Perhaps, the reason why the planet between Mars and Jupiter was not formed is that it was to be formed in the period when the sign of μ for the Sun changed. One could say with certainty that Jupiter's satellites which have inversed rotation, were formed when the sign of Jupiter's gravimagnetic field was also opposite.

7. On the Connection between Electricity and Gravity

7.1. Introduction

When Einstein moved from analyses of Electricity to analysis of Gravity, he adopted as a first postulate the concept of equivalence of gravitational field and acceleration. This means that he considered Gravity as a field of acceleration, in contrast to Electricity, which is the field of velocities. The next natural step would have been to introduce a new constant with the dimension of acceleration, which had to somehow characterize Gravity in the same sense as the speed of light characterizes Electricity.

Einstein did not go this way. We know the result: General Relativity Theory (GRT) has very limited applications.

In Paragraph 6 we propose to describe Gravity by equations of the Maxwell type in which first time derivatives are replaced by second ones. This approach leads to predictions of perihelia shifts of planets, differential rotation of the Sun and gaseous-liquid planets, the proximity of natural satellites' orbits to equatorial plane of their central body, the Earth's continental drift, the observed type of atmosphere and ocean currents, *etc*.

7.2. Historical Review

When Gauss and his assistant Weber proposed their generalization of Coulomb's law for the case of moving charges, many investigators immediately tried to apply the Gauss and Weber law to gravity. Such an approach looks quite natural because the static law of Gravity and the Coulomb formula look so similar.

The dynamic part of the Gauss and Weber law depends on the difference between velocities of electric charges. The calculations were first applied to explain the perihelion advance of Mercury's orbit. This problem was very acute at that time. Observations showed that Mercury's perihelion mysteriously shifts approximately 43″ per century beyond the much larger amount that can be accounted for by Newtonian interactions with the other planets. All earlier attempts to explain the 43″ discrepancy within the framework of the Newtonian gravitational law had no success.

But the new attempts were also unsuccessful. Weber's formula predicted 14″ per century and Gauss' formula gave 28″ per century. These attempts have been renewed recently in connection with the new wave of interest to Gauss and Weber works [32], [33]. Historically, the first one who obtained the desired 43″ was Gerber [34]. His paper was recollected [35] when Einstein also obtained 43″ within the framework of GRT. Fierce discussion followed this publication. Unfortunately, the interests of different nations and financial and scientific circles influenced the final scientific outcome of the dispute. More unfortunately, we observe something like this nowadays as well.

At last it was decided that Gerber's formula was just an adjustment to a preliminary known fact. There were two additional arguments on the side of GRT. It predicted "gravitational red shift" and "double deviation" of star light in the field of the Sun. It soon became clear that the "red shift" was actually predicted within the framework of Newtonian mechanics. But the double deviation was not, and was "confirmed" by experiment. Only nowadays do certain doubts appear. The problem is that it is impossible, even today, to clearly identify this effect against the background of non-calm Sun. The question is how Eddington and others were so lucky as to do this at the beginning of the XX^th^ century.

But the main problem of GRT today is lack of any practical application.

When the new Maxwell field theory eclipsed the Gauss approach, attempts to apply the electromagnetic approach to gravity renewed.

The first one who made an attempt was Maxwell himself. But soon he came to the conclusion that any direct analogy contradicts the law of energy conservation. He concluded this mainly because opposite signs appear in Newton and Coulomb laws: two electric charges of the same sign are repulsed and two masses are attracted.

Despite this, such attempts continued in different countries: England, France, Russia, and others. The best was the one by Heaviside [36]. It was unsuccessful, just as others, including recent ones. There are many causes for this. We mention here the one that is related to Maxwell's objections.

Field equations do not describe interactions, neither of charges nor of fields. Therefore, modern electrodynamics consist of two parts: Maxwell's equations, which describe fields, and the Lorentz formula, which describes interactions. The formulas of Gauss and Weber ([32], [33]), as well as the ones of Grassmann [8], Ampère [9], and Whittaker [10], describe interaction of current differentials. They do not need fields. It would be natural if field theory supplied us with a formula describing interaction of fields. But the Lorentz force formula takes an intermediate position. It takes one charge, called the "test charge", whose field is ignored, and defines the interaction of this test charge with the fields induced in accord with Maxwell's equations by other "ordinary" charges.

Such an approach has many drawbacks. One of them is the following: the Lorentz force formula is asymmetric. It predicts situations when charge no. 1 affects charge no. 2, but not *vice-versa*; *i.e.*, Newton's third law is violated.

One can express the idea of the Lorentz force formula differently. If, in accord with Maxwell equations, we express fields by means of charges, and put them into the Lorentz force formula, we obtain the Grassmann formula [8]. This means that if we limit ourselves to the Lorentz force formula, the entire Maxwell system becomes unnecessary, and one can always use Grassmann's formula instead of modern electrodynamics. But Grassmann's formula covers very specific cases of charge interactions. Other cases are described by other formulas, the above mentioned ones in particular.

But why was no formula describing interaction of fields proposed? I believe there were historical causes. I would mention one frequently used argument in support of the Lorentz formula. It is alleged that two fields do not interact. Example: two light beams freely intersect each other. And photons are believed to be the transmitters of fields. One objection to this assertion was mentioned above: any field induced by a charge can be expressed by means of this charge in accord with Maxwell equations. We shall come to the second objection below.

Thus we can assert that we must re-examine electrodynamics problems before we try to apply this approach to gravity.

7.3. On the Gravidynamic Field and Force

In the early 1980's, the author proposed a variational "Logarithm Principle" (Paragraph 10), in which fields, in particular the gravitational field, are described by Maxwell type equations in which first time derivatives are replaced by second time derivatives, and constant acceleration a plays the role of light speed c in electrodynamics. In the first version, a certain analog of the Lorentz force formula was adopted, but instead of electric charges and their velocities, masses and their accelerations appeared.

Already at this stage, it became possible to explain many gravity phenomena. They were well known, but to the best of our knowledge, no attempts had been made to explain them.

Most of the proposed explanations were essentially related to the gravimagnetic field that appears in the equations. For instance, movement of planets in the Sun's gravimagnetic field leads to the emergence of several forces. One force is radial, and defines planets orbits displacement. The second one is directed towards Sun equatorial plane, and drives orbits into this plane. That is why most of the orbits of natural satellites are close to the equatorial plane of the central body. Orbits behave like a current loop in an electromagnetic field. The main difference is that the forces are small and process is slow.

The third force is directed tangentially, and either enhances or counteracts the planet's movement. This very force increases or decreases the angular velocity of the planets' own rotation, depending of the sign of gravimagnetic field. Apparently, these forces produce effects in galaxies that are today ascribed to "dark mass", and they explain the following observed fact: young stars in our Galaxy rotate slowly, mature stars rotate fast enough, and old stars again rotate slowly. And the gravimagnetic field distribution in the Earth controls atmospheric and ocean currents and continental drift. The same force leads to differential rotation of the Sun and gaseous-liquid planets: equatorial regions rotate faster than polar ones.

It was clear from the very beginning that the gravimagnetic field is closely related to the electromagnetic field. Today, we understand that the magnetic and electric fields are just special cases of gravity. Thus we can discuss the magnetic field only in all the cases.

It is known that Earth's magnetic field oscillates, and even changes sign. Today we do not know the cause of such behavior, but we can state that the rate of Earth's rotation, continental drift and ocean currents are closely linked to the behavior of Earth's magnetic field.

Generalization of gravimagnetics in the way electrodynamics was generalized shows that the interaction of masses depends not only on accelerations, but also on the third and fourth time derivatives as well. Newtonian attraction appears with the correct sign in such a generalization, and predicts attraction of two masses.

8. On Gravidynamic Forces

A certain generalization of Maxwell equations was proposed in Chapter 1. It implies the use of total time derivatives instead of the partial ones. A partial solution of this system was found for the case of the fields induced by electric charges.

The scalar product of electric fields created by different charges determines their interaction energy, and the vector product of their magnetic fields determines their interaction impulse. Having calculated interaction energy gradient, we obtain interaction force as Huygens understood it, and having calculated impulse total time derivative, we obtain Newton's interaction force.

It turns out that these forces' physical meaning and mathematical description essentially differ.

The gradient part depends on the product of charges' velocities, and is equal to zero if at least one of the charges is at rest. This part incorporates force formulas proposed earlier by Ampere, Whittaker and Lorentz. The last one is usually defined by interaction of a certain charge, called "test charge" and the fields induced by the other charge. Actually it coincides with force formula proposed earlier by Grassmann. The proposed formula, in contrast to Lorentz formula, satisfies Newton's third law.

The second Newtonian part of the force formula depends on the product of the differences of the charge velocities and accelerations. Therefore it predicts interaction, in particular, between moving and standing charges, in addition to Coulomb force. It contains terms proposed earlier for force description by Gauss and Weber. As in the case of the Lorentz force formula, it adds terms that make the Gauss and Weber force symmetric. A certain part of this force is inverse in squared light velocity c^2 and a part of it is inverse in c^3. Apparently these items are essential for the electroweak interaction.

This appendix is devoted to a similar investigation of gravitational forces created by moving masses. Corresponding

fields are described by Maxwell type equations in which first time derivatives are changed for the second ones. One can say that Electricity is a field of velocities and gravity is a field of accelerations. Solutions of such a system are used to construct interaction energy and interaction impulse. The gradient of the scalar product of corresponding gravitational fields, and second time derivative of vector product of gravimagnetic fields, turn out to give accurate analogs of electrodynamic interaction. But here forces depend not only on velocities and accelerations, but also on third and fourth derivatives as well.

8.1. Equations of Gravidynamic field

Let **G** be the gravidynamic field, and **D** be the gravimagnetic field, both of which are induced by moving mass m that is distributed in space with density ρ. We assume that functions describing these fields satisfy the following equations:

$$\nabla\cdot\mathbf{G}=\gamma\rho, \tag{8.1.1}$$

$$\nabla\cdot\mathbf{D}=-\frac{\gamma\rho}{a}, \tag{8.1.2}$$

$$\nabla\times\mathbf{G}=-\frac{d^2\mathbf{D}}{dt^2}, \tag{8.1.3}$$

$$a^2\nabla\times\mathbf{D}=\frac{d^2\mathbf{G}}{dt^2}, \tag{8.1.4}$$

where γ is gravitational constant, and a is constant acceleration, playing in gravidynamics the same role that light speed c plays in electrodynamics. Thus we consider gravity as a field of accelerations, in contrast to electricity, which is a field of velocities.

System (8.1.1)–(8.1.4) is similar to generalized Maxwell equations. It provokes the same questions as the traditional Maxwell system does. The questions are: in order to find two vector-functions **G** and **D** that are unknown in system (8.1.1)–(8.1.4), we need two vector equations, not more and not less. But system (8.1.1)–(8.1.4) contains two divergence equations in addition. Accurate analysis shows that divergence correlations, as in the Maxwell system (8.1.1)–(8.1.4), are actually not equations, but initial conditions for **G** and **D** written in divergence form. Therefore, instead of (8.1.1) and (8.1.2) we shall write

$$\mathbf{G}(0,\mathbf{r})=\frac{\gamma\rho}{3}\mathbf{r}, \tag{8.1.5}$$

$$\mathbf{D}(0,\mathbf{r})=-\frac{\gamma\rho}{3a}\mathbf{r}. \tag{8.1.6}$$

We come to (8.1.1) and (8.1.2) having calculated the divergence of (8.1.5) and (8.1.6). If we want to obtain for system (8.1.3)– (8.1.4) a partial solution, we must determine initial conditions not only for the fields (8.1.5) and (8.1.6) but also initial conditions for their time derivatives. These are determined by the physical essence of the problem. We accept here zero initial conditions for them, *i.e.,*

$$\mathbf{G}'(0,\mathbf{r})=0, \tag{8.1.7}$$

$$\mathbf{D}'(0,\mathbf{r})=0. \tag{8.1.8}$$

In other terms we assume that initial impulse of the investigated mass is null. Mathematically this means that its initial velocity $d\mathbf{r}/dt$ and the initial velocity of its density change $d\rho/dt$ are zero.

Let $\mathbf{r}_0$ be the radius of the minimal sphere containing the mass m. We assume the following boundary conditions for this sphere

$$\mathbf{G}(t,\mathbf{r}_0)=-\frac{\gamma m}{4\pi r_0^3}\left[-\frac{\mathbf{r}_0\times\mathbf{w}}{a}+\mathbf{r}_0\right], \tag{8.1.9}$$

$$\mathbf{D}(t,\mathbf{r}_0)=-\frac{\gamma m}{4\pi r_0^3 a}\left[\frac{\mathbf{r}_0\times\mathbf{w}}{a}+\mathbf{r}_0\right], \tag{8.1.10}$$

where t is in the interval $[0,\infty)$, **w** is acceleration of the mass m, which is obtained by integrating ρ over a sphere of radius $\mathbf{r}_0$ that contains it.

Conditions (8.1.9)–(8.1.10) fix the fields translational and rotational movement on the minimal sphere containing m.

$\mathbf{G}(t,\mathbf{r})$ and $\mathbf{D}(t,\mathbf{r})$ are functions of time and space coordinates (x_1, x_2, x_3) which we express with the help of radius-vector **r**. Thus we search for system (8.1.3)– (8.1.4) solution with initial conditions (8.1.5)–(8.1.6), (8.1.7)–(8.1.8) and boundary conditions (8.1.9)–(8.1.10).

Let mass m, which we obtain integrating density ρ over the volume inside of which this mass is distributed, move with velocity **v** and acceleration **w**. Time derivatives will be designated by dot over the corresponding letter. Thus $\dot{\mathbf{w}}$ and $\ddot{\mathbf{w}}$ are the third and the fourth time derivatives of radius vector **r**. We assume the following limitation on the character of the movement of mass m

$$2(\mathbf{v}\times\dot{\mathbf{w}})+\mathbf{r}\times\ddot{\mathbf{w}}=0. \tag{8.1.11}$$

This condition holds for an instant in the case of motion with constant acceleration **w** or when vector **v** is collinear to $\dot{\mathbf{w}}$ and **r** is collinear to $\ddot{\mathbf{w}}$. Condition (8.1.11) holds in particular when two masses oscillate along parallel straight lines. When condition (8.1.11) holds, the system (8.1.3)–(8.1.10) has the following solution

$$\mathbf{G}=-\frac{\gamma m}{4\pi r^3}\left[-\frac{\mathbf{r}\times\mathbf{w}}{a}+\mathbf{r}\right], \tag{8.1.12}$$

$$\mathbf{D}=-\frac{\gamma m}{4\pi r^3 a}\left[\frac{\mathbf{r}\times\mathbf{w}}{a}+\mathbf{r}\right]. \tag{8.1.13}$$

Eqs. (8.1.12) and (8.1.13) show that the gravidynamic field consists of not only a static part (the second part in square brackets), but also of the dynamic curl part (the first item in square brackets).

Let two masses m_1 and m_2 move inducing fields $\mathbf{G}_1$, $\mathbf{D}_1$ and $\mathbf{G}_2$, $\mathbf{D}_2$, and let their accelerations be $\mathbf{w}_1$ and $\mathbf{w}_2$. Let $\mathbf{r}_{21} = \mathbf{r}_1 - \mathbf{r}_2$ be the radius vector from mass m_2 to mass m_1, $\mathbf{r}_1$ and $\mathbf{r}_2$ be radius vectors to masses m_1 and m_2, and $r = |\mathbf{r}_{21}|$.

We assume the following formula, which describes the forces with which fields $\mathbf{G}_2$, $\mathbf{D}_2$ act on fields $\mathbf{G}_1$, $\mathbf{D}_1$:

$$\mathbf{F}_{21}=-\nabla\left[\frac{4\pi r^3}{\gamma}(\mathbf{G}_{12}\cdot\mathbf{G}_{21})\right]+\frac{d^2}{dt^2}\left[\frac{4\pi a r^3}{\gamma}(\mathbf{D}_{12}\times\mathbf{D}_{21})\right]. \tag{8.1.14}$$

When (8.1.12)–(8.1.13) are substituted into (8.1.14), one obtains for the gradient part

$$\begin{aligned}\mathbf{F}_{21}^{1} &= -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} + \frac{\gamma m_1 m_2}{4\pi a^2 r^3}\left[\mathbf{w}_1\times(\mathbf{r}_{21}\times\mathbf{w}_2)+\mathbf{w}_2\times(\mathbf{r}_{21}\times\mathbf{w}_1)-\frac{3(\mathbf{r}_{21}\times\mathbf{w}_1)\cdot(\mathbf{r}_{21}\times\mathbf{w}_2)}{r^2}\mathbf{r}_{21}\right]= \\ &= -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} + \frac{\gamma m_1 m_2}{4\pi r^3 a^2}\left[\mathbf{w}_1(\mathbf{r}_{21}\cdot\mathbf{w}_2)+\mathbf{w}_2(\mathbf{r}_{21}\cdot\mathbf{w}_1)+2\mathbf{r}_{21}(\mathbf{w}_1\cdot\mathbf{w}_2)-\frac{3(\mathbf{r}_{21}\times\mathbf{w}_1)\cdot(\mathbf{r}_{21}\times\mathbf{w}_2)}{r^2}\mathbf{r}_{21}\right].\end{aligned} \tag{8.1.15}$$

The expression after the second equality sign is obtained by revealing the triple vector products in the previous one.

The first item here determines Newtonian static force of gravity. We have obtained it not as a generalization of experimental information, but rather as an implication of fundamental correlation between energy and force. We obtained the Coulomb force in Chapter 1 just in the same way, but in contrast to Coulomb force Newtonian force in (8.1.15) has opposite sign; *i.e.,* two masses are attracted, and not repulsed. Items in square brackets describe forces that appear because of movement of masses. The first two summands predict forces directed along accelerations of masses; the second two summands predict the appearance of forces additional to Newtonian force. They are directed along the radius vector.

All of these forces are zero if at least one of the masses is at rest, or moves with constant velocity. Actually, this is another formulation of the Newton's first law. One can name $\mathbf{F}_{21}^{2}$ the "Huygens force". We have obtained it following his concept of force as energy gradient. The difference is that he applied it to analysis of movement of a separate massive body. Formula (8.1.14) uses this idea to describe the interaction of massive bodies with the help of interaction of the fields induced by these bodies.

One can say the same words about the second, Newtonian, part of the force (8.1.14). The first time derivative of the second square brackets in (8.1.14) supplies us with the fields' interaction impulse, and the second time derivative furnishes us the force formula. After corresponding calculations, one obtains: the first part of Newtonian gravidynamic force

$$\begin{aligned}\mathbf{F}_{21}^{2} = \frac{\gamma m_1 m_2}{4\pi a^2 r^3}\Big[&(\mathbf{w}_1-\mathbf{w}_2)\times(\mathbf{r}_{21}\times(\mathbf{w}_1-\mathbf{w}_2))+2(\mathbf{v}_1-\mathbf{v}_2)\times((\mathbf{v}_1-\mathbf{v}_2)\times(\mathbf{w}_1-\mathbf{w}_2))+2(\mathbf{v}_1-\mathbf{v}_2)\times(\mathbf{r}_{21}\times(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2))+ \\ &+2\mathbf{r}_{21}\times((\mathbf{v}_1-\mathbf{v}_2)\times(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2))+\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2))+\mathbf{r}_{21}\left\{\frac{3}{r^2}\left((\mathbf{w}_1-\mathbf{w}_2)-\frac{4(\mathbf{v}_1-\mathbf{v}_2)}{r}\right)\cdot\Big((\mathbf{r}_{21}\times\mathbf{w}_1)\times\mathbf{r}_{21}+\mathbf{r}_{21}\times(\mathbf{r}_{21}\times\mathbf{w}_2)\Big)\right\}\Big].\end{aligned} \tag{8.1.16}$$

This part of the Newton's dynamic force is inverse in a^2. The second part of it is a^3 inverse, and appears as follows:

$$\begin{aligned}\mathbf{F}_{21}^{3} = \frac{\gamma m_1 m_2}{4\pi a^3 r^3}\Big[&(\mathbf{r}_{21}\times\ddot{\mathbf{w}}_2)\times(\mathbf{r}_{21}\times\mathbf{w}_1)+(\mathbf{r}_{21}\times\mathbf{w}_2)\times(\mathbf{r}_{21}\times\ddot{\mathbf{w}}_1)+(\mathbf{w}_1\times\mathbf{w}_2)\times((\mathbf{r}_{21}\times\mathbf{w}_1)-(\mathbf{r}_{21}\times\mathbf{w}_2))+2((\mathbf{v}_1-\mathbf{v}_2)\times\dot{\mathbf{w}}_2)\times \\ &\times(\mathbf{r}_{21}\times\mathbf{w}_1)+2((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_2)\times((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_1)+2((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_2)\times(\mathbf{r}_{21}\times\dot{\mathbf{w}}_1)+2(\mathbf{r}_{21}\times\mathbf{w}_2')\times((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_1)+ \\ &+2(\mathbf{r}_{21}\times\dot{\mathbf{w}}_2)\times(\mathbf{r}_{21}\times\dot{\mathbf{w}}_1)+2(\mathbf{r}_{21}\times\dot{\mathbf{w}}_2)\times((\mathbf{v}_1-\mathbf{v}_2)\times\dot{\mathbf{w}}_1)+ \\ &+\mathbf{r}_{21}\left\{\frac{3}{r^2}\left((\mathbf{w}_1-\mathbf{w}_2)-\frac{4(\mathbf{v}_1-\mathbf{v}_2)}{r}\right)\Big((\mathbf{r}_{21}\times\mathbf{w}_1)\times\mathbf{r}_{21}+\mathbf{r}_{21}\times(\mathbf{r}_{21}\times\mathbf{w}_2)\Big)\right\}\Big].\end{aligned} \tag{8.1.17}$$

As was said above, permanent acceleration a plays the same part in gravidynamics that constant light velocity c plays in electrodynamics. There are certain reasons to believe that a is not less than c numerically, and perhaps is equal to it with 2π accuracy.

One obtains revealing triple vector products in (8.1.16)

$$\begin{aligned}\mathbf{F}_{21}^{2} = \frac{\gamma m_1 m_2}{4\pi a^2 r^3}\Bigg\{&\mathbf{r}_{21}\left[(\mathbf{w}_1-\mathbf{w}_2)^2+2(\mathbf{v}_1-\mathbf{v}_2)(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)+\mathbf{r}_{21}(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2)+\frac{3}{r^2}\left((\mathbf{w}_1-\mathbf{w}_2)-\frac{4(\mathbf{v}_1-\mathbf{v}_2)}{r}\right)\Big(\mathbf{r}_{21}(\mathbf{r}_{21}(\mathbf{w}_1\times\mathbf{w}_2))\Big)\right]+ \\ &+2\cdot(\mathbf{v}_1-\mathbf{v}_2)\cdot\left[(\mathbf{v}_1-\mathbf{v}_2)\cdot(\mathbf{w}_1-\mathbf{w}_2)+\mathbf{r}_{21}\cdot(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)\right]-(\mathbf{w}_1-\mathbf{w}_2)\cdot\left[\mathbf{r}_{21}\cdot(\mathbf{w}_1-\mathbf{w}_2)+2(\mathbf{v}_1-\mathbf{v}_2)^2\right]- \\ &-4(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)[\mathbf{r}_{21}\cdot(\mathbf{v}_1-\mathbf{v}_2)]-(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2)\mathbf{r}^2\Bigg\}.\end{aligned} \tag{8.1.18}$$

The coefficient before the curly braces is equal to the corresponding coefficient before the dynamic gradient force; *i.e.,* they both have the same multiplicity. But this force depends on the differences of first, second, third and fourth time derivatives. The square brackets contain scalar products of such derivatives. The vectors pointing direction of the corresponding forces stay before the square brackets. They are radius vector derivatives of the zero, first, second, third and fourth order. All the summands, except one containing the fourth derivative, decrease as r^2. The term containing fourth derivative decreases as r. Just like the gradient part, this part contains terms directed along the radius and the "deforming" static force of gravity.

By revealing the triple vector products in (8.1.17) one obtains:

$$\mathbf{F}_{21}^{3}=\frac{\gamma m_1 m_2}{4\pi a^3 r^3}\Big\{\mathbf{r}_{21}\Big[\mathbf{r}_{21}\cdot\big((\ddot{\mathbf{w}}_2\times\mathbf{w}_1)+2(\dot{\mathbf{w}}_2\times\dot{\mathbf{w}}_1)+(\mathbf{w}_2\times\ddot{\mathbf{w}}_1)\big)+2(\mathbf{v}_1-\mathbf{v}_2)\cdot\big((\dot{\mathbf{w}}_2\times\mathbf{w}_1)+(\mathbf{w}_2\times\dot{\mathbf{w}}_1)\big)+$$
$$+\frac{3}{r^2}\left((\mathbf{w}_1-\mathbf{w}_2)-\frac{4(\mathbf{v}_1-\mathbf{v}_2)}{r}\right)\cdot\Big(\mathbf{r}_{21}\big(\mathbf{r}_{21}\cdot(\mathbf{w}_1\times\mathbf{w}_2)\big)\Big)\Big]+2(\mathbf{v}_1-\mathbf{v}_2)\big[\mathbf{r}_{21}\cdot(\dot{\mathbf{w}}_2\times\mathbf{w}_1)+(\mathbf{v}_1-\mathbf{v}_2)\cdot(\mathbf{w}_2\times\mathbf{w}_1)+ \tag{8.1.19}$$
$$+\mathbf{r}_{21}\cdot(\mathbf{w}_2\times\dot{\mathbf{w}}_1)\big]+(\mathbf{w}_2-\mathbf{w}_1)\big[\mathbf{r}_{21}\cdot(\mathbf{w}_2\times\mathbf{w}_1)\big]\Big\}.$$

This force is a^3 inverse, in contrast to the (8.1.18) force. If permanent acceleration a with which gravity moves is big enough, this means that this force is modulo less as (8.1.18) (the first part of Newtonian gravidynamic force) as dynamic part of the gradient force (8.1.15) (Huygens force). Just as in (8.1.18) vectors pointing force direction stay before square brackets in (8.1.19). They are radius vector and velocities and accelerations differences Scalar values constructed from different radius-vector time derivatives from zero up to the fourth order stay in square brackets. They determine values of the corresponding force. (8.1.19) contains items directed along radius and predicting force deforming static force just as in the case of forces (8.1.15) and (8.1.18).

In contrast to Huygens force (8.1.15) forces (8.1.18) and (8.1.19) are not zero if one of the masses is in rest or moves with constant velocity. This means that the first Newton law is not universal and a certain although small additional force appears between masses moving with constant velocities. Forces (8.1.18) and (8.1.19) does not contain static item in contrast to Huygens force (8.1.15), *i.e.*, they are zero if both masses are in rest. If masses m_1 and m_2 move with equal velocities, accelerations, the third and the fourth time derivatives force (8.1.18) is zero but in general force directed along radius is not zero in (8.1.19) expression. One obtains finally: gravidynamic force acting on mass m_1 from moving mass m_2 is

$$\mathbf{F}_{21}=\mathbf{F}_{21}^{1}+\mathbf{F}_{21}^{2}+\mathbf{F}_{21}^{3}=-\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21}+\frac{\gamma m_1 m_2}{4\pi r^3 a^2}\left[\mathbf{w}_1\times(\mathbf{r}_{21}\times\mathbf{w}_2)+\mathbf{w}_2\times(\mathbf{r}_{21}\times\mathbf{w}_1)+\frac{3(\mathbf{r}_{21}\times\mathbf{w}_1)\cdot(\mathbf{r}_{21}\times\mathbf{w}_2)}{r^2}\mathbf{r}_{21}\right]+$$
$$+\frac{\gamma m_1 m_2}{4\pi a^2 r^3}\Big[(\mathbf{w}_1-\mathbf{w}_2)\times\big(\mathbf{r}_{21}\times(\mathbf{w}_1-\mathbf{w}_2)\big)+2(\mathbf{v}_1-\mathbf{v}_2)\times\big((\mathbf{v}_1-\mathbf{v}_2)\times(\mathbf{w}_1-\mathbf{w}_2)\big)+2(\mathbf{v}_1-\mathbf{v}_2)\times\big(\mathbf{r}_{21}\times(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)\big)+$$
$$+2\mathbf{r}_{21}\times\big((\mathbf{v}_1-\mathbf{v}_2)\times(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)\big)+\mathbf{r}_{21}\times\big(\mathbf{r}_{21}\times(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2)\big)+\mathbf{r}_{21}\left\{\frac{3}{r^2}\left((\mathbf{w}_1-\mathbf{w}_2)-\frac{4}{r}(\mathbf{v}_1-\mathbf{v}_2)\right)\big((\mathbf{r}_{21}\times\mathbf{w}_1)\times\mathbf{r}_{21}+\mathbf{r}_{21}\times(\mathbf{r}_{21}\times\mathbf{w}_2)\big)\right\}\Big]+ \tag{8.1.20}$$
$$+\frac{\gamma m_1 m_2}{4\pi a^3 r^3}\Big[(\mathbf{r}_{21}\times\ddot{\mathbf{w}}_2)\times(\mathbf{r}_{21}\times\mathbf{w}_1)+(\mathbf{r}_{21}\times\mathbf{w}_2)\times(\mathbf{r}_{21}\times\ddot{\mathbf{w}}_1)+(\mathbf{w}_1\times\mathbf{w}_2)\times\big((\mathbf{r}_{21}\times\mathbf{w}_1)-(\mathbf{r}_{21}\times\mathbf{w}_2)\big)+2\big((\mathbf{v}_1-\mathbf{v}_2)\times\dot{\mathbf{w}}_2\big)\times(\mathbf{r}_{21}\times\mathbf{w}_1)+$$
$$+2\big((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_2\big)\times\big((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_1\big)+2\big((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_2\big)\times(\mathbf{r}_{21}\times\dot{\mathbf{w}}_1)+2(\mathbf{r}_{21}\times\dot{\mathbf{w}}_2)\times\big((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_1\big)+2(\mathbf{r}_{21}\times\dot{\mathbf{w}}_2)\times(\mathbf{r}_{21}\times\dot{\mathbf{w}}_1)+$$
$$+2(\mathbf{r}_{21}\times\dot{\mathbf{w}}_2)\times\big((\mathbf{v}_1-\mathbf{v}_2)\times\dot{\mathbf{w}}_1\big)+\mathbf{r}_{21}\left\{\frac{3}{r^2}\left((\mathbf{w}_1-\mathbf{w}_2)-\frac{4}{r}(\mathbf{v}_1-\mathbf{v}_2)\right)\Big((\mathbf{r}_{21}\times\mathbf{w}_1)\times\mathbf{r}_{21}+\mathbf{r}_{21}\times(\mathbf{r}_{21}\times\mathbf{w}_2)\Big)\right\}\Big].$$

We obtain the following formula revealing triple vector products here

$$\mathbf{F}_{21}=-\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21}+\frac{\gamma m_1 m_2}{4\pi a^2 r^3}\left[\mathbf{w}_1(\mathbf{r}_{21}\cdot\mathbf{w}_2)+\mathbf{w}_2(\mathbf{r}_{21}\cdot\mathbf{w}_1)+\mathbf{r}_{21}(\mathbf{w}_1\cdot\mathbf{w}_2)-\frac{3(\mathbf{r}_{21}\cdot\mathbf{w}_1)(\mathbf{r}_{21}\cdot\mathbf{w}_2)}{r^2}\mathbf{r}_{21}\right]+\frac{\gamma m_1 m_2}{4\pi a^2 r^3}\Big\{\mathbf{r}_{21}\Big[(\mathbf{w}_1-\mathbf{w}_2)^2+$$
$$+2\cdot(\mathbf{v}_1-\mathbf{v}_2)\cdot(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)+\mathbf{r}_{21}\cdot(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2)+\frac{3}{r^2}\left((\mathbf{w}_1-\mathbf{w}_2)-\frac{4(\mathbf{v}_1-\mathbf{v}_2)}{r}\right)\cdot\Big(\mathbf{r}_{21}\big(\mathbf{r}_{21}\cdot(\mathbf{w}_1\times\mathbf{w}_2)\big)\Big)\Big]+$$
$$+2\cdot(\mathbf{v}_1-\mathbf{v}_2)\cdot\big[(\mathbf{v}_1-\mathbf{v}_2)\cdot(\mathbf{w}_1-\mathbf{w}_2)+\mathbf{r}_{21}\cdot(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)\big]-(\mathbf{w}_1-\mathbf{w}_2)\cdot\big[\mathbf{r}_{21}\cdot(\mathbf{w}_1-\mathbf{w}_2)+2(\mathbf{v}_1-\mathbf{v}_2)^2\big]-$$
$$-4(\dot{\mathbf{w}}_1-\mathbf{w}_2)\big[\mathbf{r}_{21}\cdot(\mathbf{v}_1-\mathbf{v}_2)\big]-(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2)\mathbf{r}^2\Big\}+\frac{\gamma m_1 m_2}{4\pi a^3 r^3}\Big\{\mathbf{r}_{21}\Big[\mathbf{r}_{21}\cdot\big((\ddot{\mathbf{w}}_2\times\mathbf{w}_1)+2(\dot{\mathbf{w}}_2\times\dot{\mathbf{w}}_1)+(\mathbf{w}_2\times\ddot{\mathbf{w}}_1)\big)+ \tag{8.1.21}$$
$$+2(\mathbf{v}_1-\mathbf{v}_2)\cdot\big((\dot{\mathbf{w}}_2\times\mathbf{w}_1)+(\mathbf{w}_2\times\dot{\mathbf{w}}_1)\big)+\frac{3}{r^2}\left((\mathbf{w}_1-\mathbf{w}_2)-\frac{4(\mathbf{v}_1-\mathbf{v}_2)}{r}\right)\cdot\Big(\mathbf{r}_{21}\big(\mathbf{r}_{21}\cdot(\mathbf{w}_1\times\mathbf{w}_2)\big)\Big)\Big]$$
$$2(\mathbf{v}_1-\mathbf{v}_2)\big[\mathbf{r}_{21}\cdot(\dot{\mathbf{w}}_2\times\mathbf{w}_1)+(\mathbf{v}_1-\mathbf{v}_2)\cdot(\mathbf{w}_2\times\mathbf{w}_1)+\mathbf{r}_{21}\cdot(\mathbf{w}_2\times\dot{\mathbf{w}}_1)\big]+(\mathbf{w}_2-\mathbf{w}_1)\big[\mathbf{r}_{21}\cdot(\mathbf{w}_2\times\mathbf{w}_1)\big]\Big\}.$$

8.2. Examples

Example 1

Let two masses m_1 and m_2 move with equal accelerations $\mathbf{w}_1 = \mathbf{w}_2 = \mathbf{w}$ along parallel straight lines, *i.e.*,

$$\mathbf{w}_1\cdot\mathbf{w}_2=w^2. \tag{8.2.1}$$

Let angle between $\mathbf{r}_{21}$ and $\mathbf{w}_1$ be θ. It is equal to angle between $\mathbf{r}_{21}$ and $\mathbf{w}_2$. Dynamic part of Newton force is zero for such masses and gradiental part looks as follows

$$\mathbf{F}_{21} = -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} + \\ +\frac{\gamma m_1 m_2}{4\pi r^3 a^2}[2\mathbf{w} r w \cos\theta + \mathbf{r}_{21} w^2 (1-3\cos^2\theta)]. \tag{8.2.2}$$

Dynamic force directed along radius and deforming static one (second item in square brackets) depends on θ, *i.e.*, depends on the masses location with respect to each other.

When $(1-3\cos^2\theta)=0$ (*i.e.*, at about 55° and 125°), the dynamic radial force is zero. When θ is in the interval [0°, 55°], or θ is in the interval (125°, 180°), the force is negative, and reinforces the static part. When θ is in the interval [55°, 125°], the force is positive, and it weakens the static force. The force directed along acceleration (the first item in square brackets) is zero when θ = 90°, *i.e.*, if masses fly "side by side". When θ is in the interval (180°, 90°) (the first mass is behind), this force is directed along acceleration, and increases acceleration of the first mass (the second mass "helps" the first one). When θ is in the interval (90°, 0°) (the first mass is ahead), this force is directed against the first mass acceleration (the second mass "brakes" the first mass movement). Force of equal magnitude and opposite direction is applied to the second mass. This means that masses strive for moving "side by side". We observe such an effect in the movement of planets. The effect is just the strict analogue for the corresponding effect in generalized electrodynamics, where it manifests in the cluster effect in particular: when chargers velocities are high, they gather together in clusters instead of scattering because of Coulomb force.

Example 2

Let under conditions of the previous example accelerations are not constant but masses oscillate along parallel straight lines with amplitude A and angular speed ω, *i.e.*,

$$\mathbf{w}_1 = \mathbf{w}_2 = -A^2 w^2 \cos\omega t\mathbf{d}, \tag{8.2.3}$$

here **d** is unit vector determining direction of the straight lines along which oscillations take place. Newtonian dynamic force here is again zero and gradiental one looks as follows

$$\mathbf{F}_{21} = -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} + \\ +\frac{\gamma m_1 m_2 A^2 w^4 \cos^2\omega t}{4\pi r^3 a^2}[-2r\cos\theta\cdot\mathbf{d} + (1-3\cos^2\theta)\mathbf{r}_{21}]. \tag{8.2.4}$$

Here θ is again the angle between $\mathbf{r}_{21}$, and **d** is just as in the previous example.

We have obtained a formula very similar to (8.2.2). It is interesting because it shows a constructive way to "anti-gravitation". The masses should oscillate "side by side". The static gravitational force will be overcome when

$$A^2 w^4 \cos^2\omega t \ge a^2. \tag{8.2.5}$$

Example 3

Let mass m_1 rotate around static mass m_2 with constant tangential speed $\mathbf{v}_1$, *i.e.*, with constant centripetal acceleration $\mathbf{w}_1$. For this case the gradient force is zero because one of the masses is static. The greater part of the terms in Newtonian dynamic force, which contain third and fourth derivatives, are also zero. We obtain

$$\mathbf{F}_{21} = -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} + \frac{\gamma m_1 m_2}{4\pi r^3 a^2}[w_1^2\mathbf{r}_{21} + (2\mathbf{v}_1^2 - r w_1)\mathbf{w}_1]. \tag{8.2.6}$$

Taking into account that

$$\mathbf{w}_1 = -\frac{\mathbf{v}_1^2}{r^2}\mathbf{r}_{21}, \tag{8.2.7}$$

i.e., that centripetal force is anti-parallel to the radius vector, we obtain that items in square bracket in (8.2.6) are mutually annihilated and only static part remains (the first item in (8.2.6)). We could predict this result if we gazed more attentively at formula (8.1.13) which determines gravimagnetic field. The first item in it for mass m_2 is zero because it is static ($\mathbf{w}_2 = 0$), and it is also zero for m_1 because $\mathbf{w}_1$ is anti-parallel to radius vector. Vector product of radius-vector to radius-vector is zero in contrast to scalar product which participates in gradiental part of the formula where it determines static part (static Newton force).

Let us repeat the idea already mentioned above: the formula for magnetic fields interaction does not contain a static part, in contrast to the interaction formula for electric and gravitational fields.

Astronomical observations show that additional forces appear between moving planets and Sun. This means that the planets and the Sun are "gravitational ferromagnetic", *i.e.*, they are stable gravimagnets. Special investigation will be devoted to this case.

9. The Second Continuity Equation

In this paragraph, an equation generalizing the classical continuity equation for the case of accelerated motion is proposed. *It turns out to be useful in the description of gravity.*

Let **v** be fluid velocity, and ρ be its density, and Q be the total fluid inside a surface S. The time rate of change of Q, or, this is the same, the rate of the fluid leaking through a surface S, is

$$\frac{dQ}{dt} = \iint_S \rho v_n dS, \tag{9.1}$$

where v_n is the projection of **v** on the external normal to S, indicated by **n**, On the other hand, the rate of change fluid in the volume V is

$$\frac{dQ}{dt} = -\iiint_V \rho_t' dV. \tag{9.2}$$

Here and below the lower index t means partial derivative with respect to time t. With the help of Gauss' theorem, one finds for any volume V

$$-\iiint_V (\rho_t' + \nabla\cdot\rho\mathbf{v})dV = 0.$$

This is satisfied if

$$\rho_t' + \nabla\cdot\rho\mathbf{v} = 0. \tag{9.3}$$

which is the classical continuity equation. If the flow is accelerated, then the second total derivative with respect to t in (9.1) will also be non-zero. One obtains:

$$\begin{aligned} \frac{d^2Q}{dt^2} &= \iint\limits_S \left[(\rho \mathbf{v}_n)'_t + v_n(\nabla\cdot\rho v)\right]dS = \\ &= \iiint\limits_V \nabla\cdot\left[(\rho\mathbf{v})'_t + \mathbf{v}(\nabla\cdot\rho\mathbf{v})\right]dV. \end{aligned} \tag{9.4}$$

On the other hand, the acceleration with which density ρ changes in volume V is

$$\frac{d^2Q}{dt^2} = -\iiint\limits_V \rho''_{tt}\,dV, \tag{9.5}$$

i.e.,

$$\iiint\limits_V \left[\rho''_{tt} + \nabla\cdot\left[(\rho\mathbf{v})'_t + \mathbf{v}(\nabla\cdot\rho\mathbf{v})\right]\right]dV = 0 \tag{9.6}$$

for any V.

$$\rho''_{tt} + \nabla\cdot\left[(\rho\mathbf{v})'_t + v(\nabla\cdot\rho\mathbf{v})\right] = 0. \tag{9.7}$$

If the flow is steady, *i.e.*, if $\rho''_{tt} = 0$, and $\mathbf{v}'_t = 0,$, then one can easily verify that (9.7) comes to (9.3). On the whole, both equations should be valid simultaneously, and (9.3) can be used to simplify (9.7).

One gets finally

$$\rho''_{tt} + \nabla\cdot\rho\mathbf{v}'_t = 0. \tag{9.8}$$

Eqs. (9.3) and (9.8) must be valid simultaneously for accelerated processes. (9.8) becomes an identity for non-accelerated processes. Both (9.3) and (9.8) are kinematic facts, and are not dependent on any assumptions except the assumption that there are no sources of fluid inside the volume under consideration. If necessary, exactly analogous conclusions could be drawn for higher rank derivatives.

The continuity equation, Eq. (9.3), is widely used in physics, and is understood as the mathematical expression of conservation laws. The above said means that this assumption is correct only for steady processes. In particular, it is acceptable when the electric charge conservation law is obtained from Maxwell equations.

But Eq. (9.3) becomes only a necessary condition when an accelerated process, or a processes depending on the third and fourth time derivatives, is investigated. In particular, we need Eq. (9.8) when a mass conservation law is obtained from gravidynamic equations.

10. On Logarithm Principle

The proposed principle is a variational one. Variational principles have become a real philosophy of science. The most famous among them is the principle of minimum action. It is widely used to obtain physical fields' equations. The impulse to its creation was the brachistochrone problem proposed by Johann Bernoulli. This was the first step to realization that real trajectories in Nature have extremal character.

Nicolas Bernoulli proposed a problem which he called "St. Petersburg paradox". In contrast to physical brachistochrone problem had socioeconomic character and considered the problem of money utility for individuals. The very paradox shows that persons cannot use mean selecting different lotteries. Daniel Bernoulli proposed a system of axioms which solved the paradox and which implied assertion that utility function is a logarithmic one.

In paper [29] author proposed a modification of Bernoulli's axioms. This modification enables us to formulate a variational principle calls "Logarithm Principle". The aim of this principle was to find equations of "socio-economic development". But later it became clear for the author that economy and sociology are not ready for strict mathematical analyses. At last Logarithm Principle was applied to analyses of physics.

10.1. The Basis for the Logarithm Principle

Variational principles are mathematically formulated philosophical assumtions on the very general laws of Nature. Their correctness is based the validity of their consequences. It was mentioned above that the principle's consequences in socio-economic sciences were not verified because the sciences were not ready for strict mathematical analyses. Therefore only the validness of the physical fields' equations obtained with the principle assistance may be considered as its corroboration.

The Logarithm Principle yields equations for electric field potentials and heat transfer. They are widely known and verified in physical practice.

But equations of gravidynamic field which are also the principle's corollary do not coincide with General Relativity Theory, nevertheless the equations obtained from Logarithm Principle must be considered as preferable on the following basis. Newtonian law of gravity is just a natural special case for any mass and not for the mass striving to zero as it in GRT Planet's perihelium shift and gravitational red shift which are considered today as GRT corroboration are also implied into gravidynamic theory. In addition the Gravidynamic Theory of obtained from Logarithm Principle predicts many other observations explained at all today. They are: Phobos falling on Mars, the different rotation of the Sun and gasoliquid planets, the proximity of natural satellites'' orbits to equatorial planes of the central body, the Earth's continental drift, the observed type of atmosphere and ocean currents, the source of energy, the source of energy for Earth's magnetic field and some others.

10.2. The Scientific and Practical Use of the Logarithm Principle

The Logarithm Principle is the instrument which enables us to mathematically formulate and describe development of socio-economic and physical processes. Mathematically it looks as traditional principle of minimal active in which Lagrangian is changed for a logarithmic function. Let us introduce some definitions beforehand.

Let it be time, (x, y, z) is point in three dimensional Euclidian space, $\mathbf{A} = (A_1, A_2, A_3)$ is vector and φ is scalar potentials of a field. And let $\mathbf{A}$ and φ satisfy the equations

$$\frac{\partial^{2m}\mathbf{A}}{\partial x^{2m}}+\frac{\partial^{2m}\mathbf{A}}{\partial y^{2m}}+\frac{\partial^{2m}\mathbf{A}}{\partial z^{2m}}-\frac{1}{c^2}\frac{\partial^{2n}\mathbf{A}}{\partial t^{2n}}=0, \qquad (10.2.1)$$

$$\frac{\partial^{2m}\varphi}{\partial x^{2m}}+\frac{\partial^{2m}\varphi}{\partial y^{2m}}+\frac{\partial^{2m}\varphi}{\partial z^{2m}}-\frac{1}{c^2}\frac{\partial^{2n}\varphi}{\partial t^{2n}}=0. \qquad (10.2.1a)$$

where c is the field constant characterizing its movement, m, $n = 1, 2, \ldots$.

Definition. Vector-function $\mathbf{B} = (B_1, B_2, B_3)$ and function ψ satisfying the equations

$$\frac{\partial^{m}\mathbf{B}}{\partial x^{m}}+\frac{\partial^{m}\mathbf{B}}{\partial y^{m}}+\frac{\partial^{m}\mathbf{B}}{\partial z^{m}}-\frac{1}{c^2}\frac{\partial^{n}\mathbf{B}}{\partial t^{n}}=0, \qquad (10.2.2)$$

$$\frac{\partial^{m}\psi}{\partial x^{m}}+\frac{\partial^{m}\psi}{\partial y^{m}}+\frac{\partial^{m}\psi}{\partial z^{m}}-\frac{1}{c^2}\frac{\partial^{n}\psi}{\partial t^{n}}=0, \qquad (10.2.2a)$$

are called subpotentials corresponding $\mathbf{A}$ and φ. $\mathbf{A}$ and φ are called potentials corresponding $\mathbf{B}$ and ψ.

Let us consider the following variational problem

$$\int_{t_1}^{t_2}(k\ln x+p\ln x)dt. \qquad (10.2.3)$$

Here x is space variable, k and p are some integer numbers, $p > 0$, $k + p > 0$.

Euler extremal equation for (10.2.3)

$$pxx''+kx'^2=0, \qquad (10.2.4)$$

where x' is velocity and x'' is acceleration.

The total integral is

$$x=\left|c_3t+c_4\right|^{\frac{p}{k+p}},\ c_3,\ c_4=\text{const}. \qquad (10.2.5)$$

Let us raise it to the $(k + p)$ power and consider partial solution with $c_4 = 0$. We obtain

$$x^{k+p}=\left|c_3t\right|^{p}.$$

Let us consider trajectory family on the plane (x, t)

$$x^{k+p}+c_1t^p=c_2, \qquad (10.2.6)$$

where c_2 is a voluntary constant, c_1 is the constant characteristing the field. The curves (10.2.6) are characteristics of the following equation in partial derivatives

$$\frac{\partial^{k+p}\psi}{\partial x^{k+p}}-\frac{1}{c^2}\frac{\partial^{p}\psi}{\partial t^{p}}=0. \qquad (10.2.7)$$

Here $c=\dfrac{p!}{(k+p)!}c_1$. c will be called the field constant.

Logarithm Principle. Equation (10.2.7) defines a plane wave for field subpotentials for some k and p. This field's constant is c in (10.2.7).

The equation for subpotentials is

$$\frac{\partial^{k+p}\mathbf{B}}{\partial x^{k+p}}+\frac{\partial^{k+p}\mathbf{B}}{\partial y^{k+p}}+\frac{\partial^{k+p}\mathbf{B}}{\partial z^{k+p}}-\frac{1}{c}\frac{\partial^{p}\mathbf{B}}{\partial t^{p}}=0, \qquad (10.2.8)$$

$$\frac{\partial^{k+p}\psi}{\partial x^{k+p}}+\frac{\partial^{k+p}\psi}{\partial y^{k+p}}+\frac{\partial^{k+p}\psi}{\partial z^{k+p}}-\frac{1}{c}\frac{\partial^{p}\psi}{\partial t^{p}}=0, \qquad (10.2.8a)$$

The corresponding equation for potentials is

$$\frac{\partial^{2(k+p)}\mathbf{A}}{\partial x^{2(k+p)}}+\frac{\partial^{2(k+p)}\mathbf{A}}{\partial y^{2(k+p)}}+\frac{\partial^{2(k+p)}\mathbf{A}}{\partial z^{2(k+p)}}-\frac{1}{c^2}\frac{\partial^{2p}\mathbf{A}}{\partial t^{2p}}=0, \qquad (10.2.9)$$

$$\frac{\partial^{2(k+p)}\varphi}{\partial x^{2(k+p)}}+\frac{\partial^{2(k+p)}\varphi}{\partial y^{2(k+p)}}+\frac{\partial^{2(k+p)}\varphi}{\partial z^{2(k+p)}}-\frac{1}{c^2}\frac{\partial^{2p}\varphi}{\partial t^{2p}}=0. \qquad (10.2.9a)$$

Eqs. (10.2.8), (10.2.8*a*), (10.2.9), (10.2.9*a*) describe waves in empty space. For the processes with sources charges will stay in the right hand part for scalar potentials and currents for vector ones

Example 1

$k = 0$, $p = 1$.

Eq. (10.2.6) becomes

$$x+c_1t=c_2.$$

c_1 has dimension of velocity. If this is light velocity we obtain equation for electric field subpotentials in the space without charges

$$\frac{\partial\mathbf{B}}{\partial x}+\frac{\partial\mathbf{B}}{\partial y}+\frac{\partial\mathbf{B}}{\partial z}-\frac{1}{c}\frac{\partial\mathbf{B}}{\partial t}=0, \qquad (10.2.10)$$

$$\frac{\partial\psi}{\partial x}+\frac{\partial\psi}{\partial y}+\frac{\partial\psi}{\partial z}-\frac{1}{c}\frac{\partial\psi}{\partial t}=0,\ c=c_1. \qquad (10.2.11)$$

On historic reasons the concept of subpotentials was not introduced for electric field and only potentials were considered. (10.2.10) and (10.2.11) enables us to write potential equations for electric field:

$$\frac{\partial^2\mathbf{A}}{\partial x^2}+\frac{\partial^2\mathbf{A}}{\partial y^2}+\frac{\partial^2\mathbf{A}}{\partial z^2}-\frac{1}{c^2}\frac{\partial^2\mathbf{A}}{\partial t^2}=-\frac{\mathbf{j}_e}{\varepsilon_0c^2}, \qquad (10.2.12)$$

$$\frac{\partial^2\varphi}{\partial x^2}+\frac{\partial^2\varphi}{\partial y^2}+\frac{\partial^2\varphi}{\partial z^2}-\frac{1}{c^2}\frac{\partial^2\varphi}{\partial t^2}=-\frac{\rho_e}{\varepsilon_0}. \qquad (10.2.13)$$

Here $\mathbf{j}_e$ is electric current density, ρ_e is electric charges destiny, ε_0 is dielectric constant. We have obtained wave equation.

Example 2

$k = -1$, $p = 2$.

Eq. (10.2.6) is

$$x+a_1t^2=c_2.$$

a_1 has dimension of acceleration. It is natural to link the corresponding field with gravity. Subpotentials for such field in empty space look as

$$\frac{\partial \mathbf{B}}{\partial x}+\frac{\partial \mathbf{B}}{\partial y}+\frac{\partial \mathbf{B}}{\partial z}-\frac{1}{a}\frac{\partial^2 \mathbf{B}}{\partial t^2}=0, \qquad (10.2.14)$$

$$\frac{\partial \psi}{\partial x}+\frac{\partial \psi}{\partial y}+\frac{\partial \psi}{\partial z}-\frac{1}{a}\frac{\partial^2 \psi}{\partial t^2}=0,\ a=2a_1. \qquad (10.2.15)$$

In the previous section this field and its manifestations were considered in details. Gravitational potentials look as

$$\frac{\partial^2 \mathbf{A}}{\partial x^2}+\frac{\partial^2 \mathbf{A}}{\partial y^2}+\frac{\partial^2 \mathbf{A}}{\partial z^2}-\frac{1}{a^2}\frac{\partial^4 \mathbf{A}}{\partial t^4}=-\mathbf{j}_g\frac{4\pi\gamma}{a^2}, \qquad (10.2.16)$$

$$\frac{\partial^2 \varphi}{\partial x^2}+\frac{\partial^2 \varphi}{\partial y^2}+\frac{\partial^2 \varphi}{\partial z^2}-\frac{1}{a^2}\frac{\partial^4 \varphi}{\partial t^4}=\rho_g\cdot 4\pi\gamma. \qquad (10.2.17)$$

Here γ is gravitational constant, ρ_g is mass density, $\mathbf{j}_g$ is gravitational current density, a is gravitational field constant.

Example 3

$k = 1$, $p = 1$.

Eq. (10.2.6) becomes

$$x+b_1 t=c_2.$$

b_1 has dimention of diffusion coefficient. We connect the corresponding field with the concept of calory. Its subpotentials look as

$$\frac{\partial^2 \mathbf{B}}{\partial^2 x}+\frac{\partial^2 \mathbf{B}}{\partial y^2}+\frac{\partial^2 \mathbf{B}}{\partial z^2}-\frac{1}{b}\frac{\partial \mathbf{B}}{\partial t}=0, \qquad (10.2.18)$$

$$\frac{\partial^2 \psi}{\partial x^2}+\frac{\partial^2 \psi}{\partial y^2}+\frac{\partial^2 \psi}{\partial z^2}-\frac{1}{b}\frac{\partial \psi}{\partial t}=0,\ b=½b_1. \qquad (10.2.19)$$

The corresponding potentials are solutions of the following system

$$\frac{\partial^4 \mathbf{A}}{\partial x^4}+\frac{\partial^4 \mathbf{A}}{\partial y^4}+\frac{\partial^4 \mathbf{A}}{\partial z^4}-\frac{1}{b^2}\frac{\partial^2 \mathbf{A}}{\partial t^2}=-\frac{\alpha\mathbf{j}}{b^2}, \qquad (10.2.20)$$

$$\frac{\partial^4 \varphi}{\partial x^4}+\frac{\partial^4 \varphi}{\partial y^4}+\frac{\partial^4 \varphi}{\partial z^4}-\frac{1}{b^2}\frac{\partial^2 \varphi}{\partial t^2}=-\alpha\rho_g. \qquad (10.2.21)$$

Here α characterizes this field in ether, $\mathbf{j}$ is the current. Its definition demands additional consideration.

CHAPTER 3: THERMODYNAMICS

11. Introduction to Chapter 3

In 1969 symposium on thermodynamics took place in the USA. That's what Stuart, Gal-Or and Brainard write in the preface to its Proceedings: "A growing number of scientists believe today that the very foundation of present-day thermodynamic theories should be reexamined and perhaps modified. The constant search towards better thermodynamic theories is not merely a logical necessity, but is mainly due to the failure of classical, statistical and relativistic thermodynamics to solve and eliminate the existing problems, inconsistencies and paradoxes inherent in present-day thermodynamic theories…"

All the paragraphs below are an attempt to answer this necessity and solve the problem at least partly. This author believes that the first step on the way to find the answer is reexamination of the initial assumptions of the present-day theory and the only base for such reexamination can be clear physical sense of the thermodynamic processes. The basis for such understanding in the electrodynamic part of the book was introduction of mechanic dimensions for electrodynamic values. Introduction of mechanic dimensions for thermodynamic values is the foundation for understanding here. The concept of surfacive velocity immediately leads to understanding of Brownian movement and physical sense of temperature.

In addition it becomes immediately clear that heat has dimension of frequency. The frequency of what? The answer comes naturally: the thermodynamic charge frequency. The thermodynamic charge is understood as axial vector modulo equal to Planck's constant.

But what is thermodynamic process? Why should we limit ourselves with only not completely understandable? The answer is: such is the definition of entropy. But perhaps present-day entropy definition and correspondingly its physical meaning is not satisfactory? Perhaps a generalized definition can be proposed which fits equilibrium processes and can be used for non-equilibrium ones? Such definition is proposed and it turns to be quite analogous to the light wave description.

The non-equilibrium processes consideration puts a problem of the medium in which it takes place. It becomes clear that there are media in which efficiency coefficient is bigger than one. The corresponding characteristics for such media are formulated. One can say this in another way: it becomes clear that we can not only lose energy in thermodynamic processes but also obtain it from the field. Characteristics of liquid helium are considered as an example contradicting the second law of thermodynamics.

Surfacive movement concept puts a question of present-day rotation description. An idea of three-dimension vector rotation is proposed. It helps to solve some problems connecting with Euler's angles and light wave description. It becomes clear that light wave is rather thermodynamic that electric phenomenon.

12. On the Vector Angle

A concept of vector angle has not been introduced in mechanics up till now. Rotation in a fixed plane is described in terms of antisymmetric tensor or vector product. Three-dimensional rotation is described with the help of Euler's angles [43]. But in addition to its bulkiness this method meets some principal problems: necessity to use only "small angles" and these angles' noncommutativity. As these authors believes a concept of vector angle deprived of these problems is proposed in this article.

12.1. Necessary Mathematical Apparatus

Developments in real three dimensional physical spaces are usually described mathematically as follows. The set

$$\mathrm{X}=\otimes X_i,\ i=1,2,3, \tag{12.1.1}$$

which is direct topological product of three real numerical lines. Axioms of linear space are naturally defined on X. Usually unit polar vectors $\mathbf{i}, \mathbf{j}, \mathbf{k}$ directed along axis X_1, X_2, X_3 correspondingly are taken as orthonormal basis. Radius-vector in such three-dimensional space is defined by its projections

$$\mathbf{r}=x_1\mathbf{i}+x_2\mathbf{j}+x_3\mathbf{k},\ x_1\in X_1, x_2\in X_2, x_3\in X_3. \tag{12.1.2}$$

Its module

$$|\mathbf{r}|=\sqrt{x_1^2+x_2^2+x_3^2} \tag{12.1.3}$$

defines Euclidian metric on X.

Let us consider three following sets in addition to X:

$$\mathrm{Y}=\otimes Y_i,\ i=1,2,3, \tag{12.1.4}$$

where

$$Y_1=X_2\otimes X_3',\ Y_2=X_3'\otimes X_1,\ Y_3=X_1\otimes X_2'. \tag{12.1.5}$$

Here X and X′, $\mathrm{X}=(X_1, X_2, X_3)$, $\mathrm{X}'=(X_1', X_2', X_3')$ are axial coordinate system identicaly put on each other. As above symbol ⊗ means direct set product. One can say that the developments in the same three-dimensional space we are going to describe in terms of coordinate planes. One can directly verify that Y in (1.4) is a linear space.

Really sum $\mathbf{y}^1+\mathbf{y}^2$, $\mathbf{y}^1, \mathbf{y}^2\in \mathrm{Y}$ in traditional sense corresponds two points $\mathbf{y}^1=(y_1^1, y_2^1, y_3^1)$ and $\mathbf{y}^2=(y_1^2, y_2^2, y_3^2)$ which also belong to Y. Vector $\alpha\mathbf{y}$ corresponds to any number α and vector $\mathbf{y}$: all elements $\mathbf{y}$ are multiplied by α. Vector $\mathbf{0}$ identically equal zero plays role of zero.

One can introduce already axial orthonormal basis in Y using polar basis $\mathbf{i}, \mathbf{j}, \mathbf{k}$ in Xand $\mathbf{i}', \mathbf{j}', \mathbf{k}'$ in X′.

$$\mathbf{l}=\mathbf{j}\times\mathbf{k}',\ \mathbf{m}=\mathbf{k}\times\mathbf{i}',\ \mathbf{n}=\mathbf{i}\times\mathbf{j}'. \tag{12.1.6}$$

Radius-vector of point $\mathbf{y}$ in Y

$$\mathbf{R} = y_1\mathbf{l} + y_2\mathbf{m} + y_3\mathbf{n}. \tag{12.1.7}$$

Its module

$$|\mathbf{R}| = \sqrt{y_1^2 + y_2^2 + y_3^2} = \sqrt{x_2^2 x_3'^2 + x_1^2 x_3'^2 + x_1^2 x_2'^2}. \tag{12.1.8}$$

A trajectory $\mathbf{y}(t) \in$ Y corresponds to any trajectory $\mathbf{x}'(t)$ in X′. The corresponding mapping is defined by tensor

$$\mathbf{y}(t) = A(\mathbf{x}'(t)) = \begin{pmatrix} 0 & x_3 & x_2 \\ x_3 & 0 & x_1 \\ x_2 & x_1 & 0 \end{pmatrix} \begin{pmatrix} x_1'(t) \\ x_2'(t) \\ x_3'(t) \end{pmatrix}. \tag{12.1.9}$$

Actually we have prescribed a new characteristic to the movement $\mathbf{x}'(t) \in$ X′. We shall see soon that such characteristic is vector angle, describing rotation of moving point. Axial coordinates x_i and x_i' coincide. For instance points (x_1; x_2') and (x_1'; x_2) in Y_3 plane coincide, *i.e.* thet defines the same point $y_3 \in Y_3$. But when we express $y_2 \in Y_2$ with the help of axis, *i.e.* define point (x_2; x_3'), generaly speaking we can't take x_2 as the x_2' ifconstructing y_3 we had taken the pair (x_1; x_2'). Let us say this in the other way. We need six axis to construct threedimensial plane coordinate system. The problems appearing when we construct plane system with the help of three axis (coordination demand) is considered below.

12.2. Definition of the term 'Vector Angle'

Let us consider the plane $Y_3 = X_1 \otimes X_2'$ and any point (x_1, x_2') on it (fig. 12.2.1).

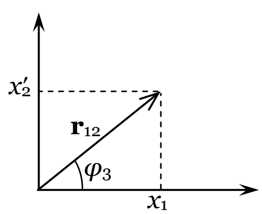


Fig. 12.2.1. Y_3 plane.

Area $x_1 \cdot x_2'$ normalized by squared radius

$$r_{12}^2 = x_1^2 + x_2'^2, \tag{12.2.1}$$

defines angle φ_3 sine and cosine product

$$\frac{x_1 x_2'}{r_{12}^2} = \sin\varphi_3 \cdot \cos\varphi_3 = \frac{1}{2}\sin 2\varphi_3. \tag{12.2.2}$$

Let z_3 be the left part of (12.2.2). One obtains

$$\sin 2\varphi_3 = 2z_3. \tag{12.2.3}$$

Let us find function

$$\arcsin(\sin 2\varphi_3) = \arcsin 2z_3. \tag{12.2.3a}$$

One obtains

$$\varphi_3 = \int \frac{dz_3}{\sqrt{1 - 4z_3^2}}. \tag{12.2.4}$$

We have found a projection of three-dimensional vector angle $\boldsymbol{\varphi} = (\varphi_1, \varphi_2, \varphi_3)$ on the plane Y_3, expressed by this plane coordinate $y_3 = x_1 \cdot x_2$. We obtain other projections in the same way

$$\varphi_1 = \int \frac{dz_1}{\sqrt{1 - 4z_1^2}}. \tag{12.2.5}$$

$$\varphi_2 = \int \frac{dz_2}{\sqrt{1 - 4z_2^2}}, \tag{12.2.6}$$

The sign in the right hand (12.2.4), (12.2.6) defines the direction of the angle counting. In future we shall take "+".

Vector angle set Φ is subspace of the space Y with the same basis ($\mathbf{l}$, $\mathbf{m}$, $\mathbf{n}$). Norm of its elements is

$$|\boldsymbol{\varphi}| = \sqrt{\varphi_1^2 + \varphi_2^2 + \varphi_3^2}, \tag{12.2.7}$$

Scalar and vector products are

$$\boldsymbol{\varphi}^1 \cdot \boldsymbol{\varphi}^2 = \frac{\varphi_1^1\varphi_1^2 + \varphi_2^1\varphi_2^2 + \varphi_3^1\varphi_3^2}{|\varphi^1| \cdot |\varphi^2|}, \tag{12.2.8}$$

$$\boldsymbol{\varphi}^1 \times \boldsymbol{\varphi}^2 = \begin{vmatrix} \mathbf{l} & \mathbf{m} & \mathbf{n} \\ \varphi_1^1 & \varphi_2^1 & \varphi_3^1 \\ \varphi_1^2 & \varphi_2^2 & \varphi_3^2 \end{vmatrix}. \tag{12.2.9}$$

Total time derivative of (12.2.4)–(12.2.6) supplies us with vector angular velocity

$$\omega_3 = \frac{1}{\sqrt{1 - 4z_3^2}} \frac{dz_3}{dt} = \frac{\dot{x}_2 x_1' - \dot{x}_1' x_2}{x_1'^2 + x_2^2}. \tag{12.2.10}$$

One obtains in the same way other projections

$$\omega_2 = \frac{\dot{x}_2' x_3 - \dot{x}_3 x_2'}{x_3^2 + x_2'^2}. \tag{12.2.11}$$

$$\omega_1 = \frac{\dot{x}_3' x_1 - \dot{x}_1 x_3'}{x_1^2 + x_3'^2}. \tag{12.2.12}$$

We can obtain angular accelerations differentiating (12.2.10)–(12.2.12).

$$\varepsilon_3 = \frac{d\omega_3}{dt} = \frac{x_1'}{x_1'^2 + x_2^2}\ddot{x}_2 + \frac{2x_1'x_2}{(x_1'^2 + x_2^2)^2}(\dot{x}_2^2 - \dot{x}_1'^2) + \frac{x_2}{x_1'^2 + x_2^2}\ddot{x}_1', \tag{12.2.13}$$

$$\varepsilon_2 = \frac{d\omega_2}{dt} = \frac{x_3}{x_2'^2 + x_3^2}\ddot{x}_1 + \frac{2x_2'x_3}{(x_2'^2 + x_3^2)^2}(\dot{x}_2'^2 - \dot{x}_3^2) + \frac{x_2'}{x_2'^2 + x_3^2}\ddot{x}_3, \tag{12.2.14}$$

$$\varepsilon_1 = \frac{d\omega_1}{dt} = \frac{x_1}{x_1^2 + x_3'^2}\ddot{x}_3' + \frac{2x_1x_3'}{(x_1^2 + x_3'^2)^2}(\dot{x}_3'^2 - \dot{x}_1^2) + \frac{x_3'}{x_1^2 + x_3'^2}\ddot{x}_1. \tag{12.2.15}$$

Here $\boldsymbol{\varepsilon} = (\varepsilon_1, \varepsilon_2, \varepsilon_3)$ is angular vector acceleration.

We have expressed rotation with the help of "length" space characteristics.

12.3. The Link between the Descriptions of Movement in the Space of Lengths and the Space of Angles

1. Direct problem.

It is necessary to describe rotation in angular space knowing its characteristics in length space.

Solution: direct substitution in the right hand part of (12.2.10)–(12.2.12).

Let $\psi_1(t) = \nu_1 t$, $\psi_2(t) = \nu_2 t$, $\psi_3(t) = \nu_3 t$ be direction cosines in the length space, ν_i $(i = 1, 2, 3)$ are angular velocities, *i.e.*, the movement is defined by the equations

$$x_1 = r\cos(\nu_1 t),\ x_2 = r\cos(\nu_2 t),\ x_3 = r\cos(\nu_3 t). \qquad (12.3.1)$$

Here r is radius-vector modulus and t is time.

$$\begin{aligned} \dot{x}_1 &= \upsilon\cos(\nu_1 t) - \nu_1 r\sin(\nu_1 t), \\ \dot{x}_2 &= \upsilon\cos(\nu_2 t) - \nu_2 r\sin(\nu_2 t), \\ \dot{x}_3 &= \upsilon\cos(\nu_3 t) - \nu_3 r\sin(\nu_3 t). \end{aligned} \qquad (12.3.2)$$

Here υ is velocity modulus. Thus the first items describe rectilinear part of the motion and the second ones its torsion al part.

One obtains substituting (12.3.1)–(12.3.2) into (12.2.10)–(12.2.12):

$$\begin{aligned} \omega_3 &= \frac{\nu_1\sin(\nu_1 t)\cos(\nu_2 t) - \nu_2\sin(\nu_2 t)\cos(\nu_1 t)}{\cos^2(\nu_1 t) + \cos^2(\nu_2 t)}, \\ \omega_2 &= \frac{\nu_3\sin(\nu_3 t)\cos(\nu_1 t) - \nu_1\sin(\nu_1 t)\cos(\nu_3 t)}{\cos^2(\nu_1 t) + \cos^2(\nu_3 t)}, \\ \omega_1 &= \frac{\nu_2\sin(\nu_2 t)\cos(\nu_3 t) - \nu_3\sin(\nu_3 t)\cos(\nu_2 t)}{\cos^2(\nu_2 t) + \cos^2(\nu_3 t)}. \end{aligned} \qquad (12.3.3)$$

The rectilinear part of the motion has disappeared. Here we do not distinguish points $x_i \in X_i$ and $x_i' \in X_i'$ because initialy we constructed movement considering X_i and X_i' as identical ones.

2. Inverse problem.

It is necessary to describe rotation in the length space knowing angular velocity in the angular one.

The following functions are solutions of system (12.2.10)–(12.2.12)

$$\begin{cases} x_3 = r_1\cos(\omega_1 t + C_1),\ x_2 = r_1\sin(\omega_1 t + C_1), \\ x_3' = r_1\sin(\omega_1 t + C_1),\ x_2' = r_1\cos(\omega_1 t + C_1), \\ r_1 = \sqrt{x_2^2 + x_3'^2}; \end{cases} \qquad (12.3.4)$$

$$\begin{cases} x_1 = r_2\cos(\omega_2 t + C_2),\ x_3 = r_2\sin(\omega_2 t + C_2), \\ x_1' = r_2\sin(\omega_2 t + C_2),\ x_3' = r_2\cos(\omega_2 t + C_2), \\ r_2 = \sqrt{x_3^2 + x_1'^2}; \end{cases} \qquad (12.3.5)$$

$$\begin{cases} x_2 = r_3\sin(\omega_3 t + C_3),\ x_1 = r_3\cos(\omega_3 t + C_3), \\ x_2' = r_3\cos(\omega_3 t + C_3),\ x_1' = r_3\sin(\omega_3 t + C_3), \\ r_3 = \sqrt{x_1^2 + x_2'^2}. \end{cases} \qquad (12.3.6)$$

Coordinates (12.3.4)–(12.3.6) with identical indices are not equal in different expressions, *i.e.*, they are not projections of a radius-vector in length space on axises. The cause of it is understandable: ω_i $(i = 1, 2, 3)$ are defined on coordinate planes and a point on a plane cannot uniquely define a point on an axis. We are compelled to demand validness of coordination condition for (12.3.4)–(12.3.6), *i.e.* coordinates with identical indices are equal. Then, from geometric considerations the following relation for angular velocities takes place:

$$\tan(\omega_3 t + C_3)\cdot\tan(\omega_2 t + C_2)\cdot\tan(\omega_1 t + C_1) = 1. \qquad (12.3.7)$$

This condition for angles looks as follows:

$$\tan\varphi_3(t)\cdot\tan\varphi_2(t)\cdot\tan\varphi_1(t) = 1. \qquad (12.3.7a)$$

We have actually proved two theorems.

Direct theorem. To any rotation with angular velocity $\mathbf{\nu}$ in the length space corresponds a rotation with angular velocity $\boldsymbol{\omega}$ in the angular space.

Inverse theorem. In order a rotation with angular velocity $\boldsymbol{\omega}$ in the angular space corresponds to an angular velocity $\mathbf{\nu}$ in the length space, it is necessary and sufficient that $\boldsymbol{\omega}$ components satisfy condition (12.3.7).

The geometric cause of such asymmetry is that any motion in the length space is described as trajectory and in the angular space as a surficial one. One can suppose that quantum particle motion needs just surficial description.

12.4. Vector product of vectors from the length space and the angle space.

When rotation along circles is considered they usually say about vector product of radius-vector and angular velocity

$$\mathbf{r}\times\boldsymbol{\omega} = (x_1, x_2, x_3)\begin{pmatrix} 0 & -\omega_3 & \omega_2 \\ \omega_3 & 0 & -\omega_1 \\ -\omega_2 & \omega_1 & 0 \end{pmatrix} = \\ = (x_2\omega_3 - x_3\omega_2, -x_1\omega_3 + x_3\omega_1, x_1\omega_2 - x_2\omega_1). \qquad (12.4.1)$$

Vector angle theory obtains angular velocity as vector angle time derivative, *i.e.*, we start not from tensor correlation (12.4.1) with angular velocity but from equality

$$\mathbf{r}\times\boldsymbol{\varphi} = (x_1, x_2, x_3)\begin{pmatrix} 0 & -\varphi_3 & \varphi_2 \\ \varphi_3 & 0 & -\varphi_1 \\ -\varphi_2 & \omega_1 & 0 \end{pmatrix} = \\ = (x_2\varphi_3 - x_3\varphi_2, -x_1\varphi_3 + x_3\varphi_1, x_1\varphi_1 - x_2\varphi_1), \qquad (12.4.1a)$$

which describes radius-vector rotation.

If r is constant we obtain

$$\frac{d}{dt}(\mathbf{r}\times\boldsymbol{\varphi}) = \mathbf{r}\times\boldsymbol{\omega},$$

We have come to traditional understanding.

There is a drawback in such definition: the orts are not indicated here. They usually avoid the problem reducing it to mnemonic rule:

$$\mathbf{r}\times\boldsymbol{\omega}=\begin{vmatrix}\mathbf{i} & \mathbf{j} & \mathbf{k}\\ x_1 & x_2 & x_3\\ \omega_1 & \omega_2 & \omega_3\end{vmatrix}=\mathbf{i}(x_2\omega_3-x_3\omega_2)+\mathbf{j}(-x_1\omega_3+x_3\omega_1)+\mathbf{k}(x_1\omega_2-x_2\omega_1). \tag{12.4.2}$$

Eqs. (12.4.1) and (12.4.2) describe rotation in a fixed plane. In order to describe three-dimensional rotation usually Euler's angles are used [44]. We shall not stop on the problems of such description; the corresponding specialists know them very well [45]–[47]. Let us consider the problems which appear in the concept of vector angles.

The problem is that when we define product for vectors from length and angles spaces we must take into account the orts in the spaces. Otherwise we are not able to define direction of the obtained product.

Definition. Vector product of radius-vector **r** and vector angle **φ** is defined by the equality

$$\begin{aligned}\mathbf{r}\boxtimes\boldsymbol{\varphi}&=\begin{vmatrix}1 & 1 & 1\\ x_1\mathbf{i} & x_2\mathbf{j} & x_3\mathbf{k}\\ \varphi_1\mathbf{l} & \varphi_2\mathbf{m} & \varphi_3\mathbf{n}\end{vmatrix}=x_2\varphi_3(\mathbf{j}\times\mathbf{n})-x_3\varphi_2(\mathbf{k}\times\mathbf{m})-x_1\varphi_3(\mathbf{i}\times\mathbf{n})+x_3\varphi_1(\mathbf{k}\times\mathbf{l})+x_1\varphi_2(\mathbf{i}\times\mathbf{m})-x_2\varphi_1(\mathbf{j}\times\mathbf{l})=\\ &=(x_2\varphi_3+x_3\varphi_2)\mathbf{i}+(x_3\varphi_1+x_1\varphi_3)\mathbf{j}+(x_1\varphi_2+x_2\varphi_1)\mathbf{k}=\\ &=(x_2\varphi_3-x_3\varphi_2)\mathbf{i}+(x_3\varphi_1-x_1\varphi_3)\mathbf{j}+(x_1\varphi_2-x_2\varphi_1)\mathbf{k}+2(x_3\varphi_2)\mathbf{i}+2(x_1\varphi_3)\mathbf{j}+2(x_2\varphi_1)\mathbf{k}.\end{aligned} \tag{12.4.3}$$

This is in tensor interpretation

$$\begin{aligned}\mathbf{r}\boxtimes\boldsymbol{\varphi}&=(x_1,x_2,x_3)\begin{pmatrix}0 & \varphi_3 & \varphi_2\\ \varphi_3 & 0 & \varphi_1\\ \varphi_2 & \varphi_1 & 0\end{pmatrix}=\begin{pmatrix}x_2\omega_3+x_3\varphi_2\\ x_1\varphi_3+x_3\varphi_1\\ x_1\varphi_2+x_2\varphi_1\end{pmatrix}^{\mathrm{T}}=\\ &=\begin{pmatrix}x_2\omega_3-x_3\varphi_2+2x_3\varphi_2\\ x_1\varphi_3-x_3\varphi_1+2x_1\varphi_3\\ x_1\varphi_2-x_2\varphi_1+2x_2\varphi_1\end{pmatrix}^{\mathrm{T}}.\end{aligned} \tag{12.4.4}$$

r is multiplied by symmetric tensor.

Thus if we want to take into account the rotation plane movement in three-dimensional space we must multiply radius-vector **r** not by antisymmetric but symmetric tensor. Let symmetric tensor in (12.4.3) be A and antisymmetric tensor in (12.4.1*a*) be B. Let us introduce a tensor in addition

$$C=\begin{pmatrix}0 & \varphi_3 & 0\\ 0 & 0 & \varphi_1\\ \varphi_2 & 0 & 0\end{pmatrix}. \tag{12.4.5}$$

Vector product can be rewritten in the following tensor way

$$\mathbf{r}\boxtimes\boldsymbol{\varphi}=\mathbf{r}A=\mathbf{r}B+2\mathbf{r}C. \tag{12.4.6}$$

Three-dimensional rotation here is described as a rotation in fixed plane (traditional definition) and an additional rotation of the plane. We shall see soon that this addition is connected with precession. We shall call it precession therefore.

The velocity of movement (12.4.3)

$$\begin{aligned}\frac{d}{dt}(\mathbf{r}\boxtimes\boldsymbol{\varphi})&=\begin{vmatrix}1 & 1 & 1\\ v_1\mathbf{i} & v_2\mathbf{j} & v_3\mathbf{k}\\ \varphi_1\mathbf{l} & \varphi_2\mathbf{m} & \varphi_3\mathbf{n}\end{vmatrix}+\begin{vmatrix}1 & 1 & 1\\ x_1\mathbf{i} & x_2\mathbf{j} & x_3\mathbf{k}\\ \omega_1\mathbf{l} & \omega_2\mathbf{m} & \omega_3\mathbf{n}\end{vmatrix}=\\ &=\mathbf{i}(v_2\varphi_3+v_3\varphi_2+x_2\omega_3+x_3\omega_2)+\\ &+\mathbf{j}(v_1\varphi_3+v_3\varphi_1+x_1\omega_3+x_3\omega_1)+\\ &+\mathbf{k}(v_1\varphi_2+v_2\varphi_1+x_1\omega_2+x_2\omega_1).\end{aligned} \tag{12.4.7}$$

Here v_i, ω_i (i = 1, 2, 3) are velocities and angular velocities of the considered point.

Its acceleration is

$$\begin{aligned}\frac{d^2}{dt^2}(\mathbf{r}\boxtimes\boldsymbol{\varphi})&=\begin{vmatrix}1 & 1 & 1\\ a_1\mathbf{i} & a_2\mathbf{j} & a_3\mathbf{k}\\ \varphi_1\mathbf{l} & \varphi_2\mathbf{m} & \varphi_3\mathbf{n}\end{vmatrix}+2\begin{vmatrix}1 & 1 & 1\\ v_1\mathbf{i} & v_2\mathbf{j} & v_3\mathbf{k}\\ \omega_1\mathbf{l} & \omega_2\mathbf{m} & \omega_3\mathbf{n}\end{vmatrix}+\\ &+\begin{vmatrix}1 & 1 & 1\\ x_1\mathbf{i} & x_2\mathbf{j} & x_3\mathbf{k}\\ \varepsilon_1\mathbf{l} & \varepsilon_2\mathbf{m} & \varepsilon_3\mathbf{n}\end{vmatrix}.\end{aligned} \tag{12.4.8}$$

Here a_i, ε_i (i = 1, 2, 3) are projection of acceleration and angular acceleration on the axises in the space of length and the planes in the space of angles correspondingly.

12.5. Examples

Example #1. Rotation of massive point on rubber thread in a fixed plane.

Let it be plane $Y_1 = X_1 \otimes X_3$, *i.e.*, rotation takes place around X_1 axis. In accordance with (12.2.12) and (12.4.2) velocity of such a point is

$$u=\begin{vmatrix}\mathbf{i} & \mathbf{j} & \mathbf{k}\\ 0 & v_2 & v_3\\ \varphi_1 t & 0 & 0\end{vmatrix}+\begin{vmatrix}\mathbf{i} & \mathbf{j} & \mathbf{k}\\ 0 & x_2 & x_3\\ \omega_1 & 0 & 0\end{vmatrix}. \tag{12.5.1}$$

The first item here defines rotation because of the thread dilation with velocity $\mathbf{v} = (0, v_2, v_3)$ and the second one because of angular velocity $\boldsymbol{\omega} = (\omega_1, 0, 0)$. Y_1 is fixed in space. Therefore traditional form of vector product is used: rotation takes place without precession. Such supposition is certainly an idealization. We usually observe precession in experiments if special measures are not taken to suppress it.

Example #2. Gyroscope precession.

Let the main rotation takes place around X_1 axis. Eq. (12.2.12) defines its angular velocity. Eq. (12.2.11) and (12.2.10) describe precession and nutation. If coordinate x_1 is fixed $(\dot{x}_1 = 0)$ then nutation is absent, *i.e.,* precession is regular. If $\mathbf{r}$ is radius vector of any rigid top point then the velocity is defined by the second determinant in (12.4.7). If the top is distorted the whole expression (12.4.7) describes the process. The velocity $\mathbf{v} = (v_1, v_2, v_3)$ is the velocity of deformation.

Example #3. Light wave.

Today light wave description meets some difficulties.

1. Experiment show [48, §84] that linearly polarized light wave is transverse. The conclusion is that any light wave is transverse. Transverse waves are possible only in rigid matter. But the space around us is not filled with rigid matter.

2. In general light wave is polarized nonlinearly but rotates along ellipse or circle [48, §88], [49, Ch.33-1]. Why do linearizing of such movement becomes transverse? And how this transverseness is coordinated to elliptic rotation?

3. Light wave comes by pulsations (photons). In order to coordinate this fact to traditional concept of wave an idea about dual principle in nature was proposed: wave-particle [48, Ch.17], [49, Ch.38].

All this questions find answers if the light wave is three-dimensional torsional wave.

1. Projections of such a rotation on coordinate planes are circles with pulsating radius. These circles are projected on any plane fixed in space as an ellipse with pulsating radius.

2. Radius' pulsations in linear projections look as transverse oscillations.

3. Not only coordinate planes' radius-vectors pulsate the very radius $\mathbf{r}$ in lengths' space also pulsate (12.4.7). Such wave comes to detector by portions (photons).

Point velocity in such wave is defined by (12.4.7) plus uniform motion with light velocity

$$u = \mathbf{i}c + \begin{vmatrix} 1 & 1 & 1 \\ v_1\mathbf{i} & v_2\mathbf{j} & v_3\mathbf{k} \\ \varphi_1 t\mathbf{l} & \varphi_2 t\mathbf{m} & \varphi_3 t\mathbf{n} \end{vmatrix} + \begin{vmatrix} 1 & 1 & 1 \\ x_1\mathbf{i} & x_2\mathbf{j} & x_3\mathbf{k} \\ \omega_1\mathbf{l} & \omega_2\mathbf{m} & \omega_3\mathbf{n} \end{vmatrix}. \quad (12.5.2)$$

13. The Field View on Thermodynamics

13.1. Necessary Mathematical Apparatus

Let us repeat our scheme for greater clarity. As a first step coordinate planes were introduced instead of coordinate axes. Pseudovectors $\mathbf{l}$, $\mathbf{m}$, $\mathbf{n}$ are normals to these planes. Let us note that although the points in the new space Y are characterized by six coordinates of the initial three dimensional space X, we do not leave three dimensional space because 3 additional constraints are put on the x points which define y points. For instance, definition of points $y_1(x_2, x_3)$ and $y_2(x_1, x_3)$ contains the same coordinate x_3. But although the unique point $y(y_1, y_2, y_3)$ corresponds to any point $x(x_1, x_2, x_3)$ and the unique trajectory $y(t)$ corresponds to any trajectory $x(t)$ the inverse assertion is invalid: a family of trajectories correspond to any trajectory in Y.

This fact solves some paradoxes in quantum mechanics: the dual character of the concepts of wave and particle, the capability for electron to be at different space points at the same time, *etc.* The cause is that trajectories in X space turn out to be twisted. The above said can be applied to rotation spaces Φ and Ψ: rotation in Φ defines the only rotation in Ψ, the inverse assertion is invalid.

The movement of a ball or a bullet is an example of movement in spaces X and Φ. The movement of a Brownian particle or an electron in atom is an example of movement in spaces Y and Ψ. Accurate investigation of physical causes of these different types of movement is to be done later.

Let us explain the said above. Let us calculate velocity in Y differentiating radius-vector $\mathbf{R} = y_1\mathbf{l} + y_2\mathbf{m} + y_3\mathbf{n}$ with respect to time:

$$\begin{aligned} \frac{d\mathbf{R}}{dt} &= \mathbf{l}\frac{dy_1}{dt} + \mathbf{m}\frac{dy_2}{dt} + \mathbf{n}\frac{dy_3}{dt} = \\ &= \mathbf{l}(x_2v_3 + x_3v_2) + \mathbf{m}(x_1v_3 + x_3v_1) + \mathbf{n}(x_1v_2 + x_2v_1). \end{aligned} \quad (13.1.1)$$

Here $\mathbf{v} = (v_1, v_2, v_3)$ is a velocity in X. Velocity (13.1.1) can be described with the help of tensor. It is described by the symmetric tensor

$$A = \begin{pmatrix} 0 & x_3 & x_2 \\ x_3 & 0 & x_1 \\ x_2 & x_1 & 0 \end{pmatrix}, \quad (13.1.2)$$

applied to velocities in X, *i.e.,*

$$\frac{d\mathbf{R}}{dt} = A(\mathbf{v}) = \begin{pmatrix} 0 & x_3 & x_2 \\ x_3 & 0 & x_1 \\ x_2 & x_1 & 0 \end{pmatrix} \begin{pmatrix} v_1 \\ v_2 \\ v_3 \end{pmatrix} \quad (13.1.3)$$

When we speak about a second rank tensor, we actually speak about a surface. Therefore, velocities (13.1.1) and (13.1.3) are called surfalinear, or thermodynamic or wave velocities. The ground for the second and third names will become clearer later.

And what type of movement corresponds to surfalinear, or simply surfacive, velocity? Rotation movement in X is usually described by vector product

$$\mathbf{r} \times \mathbf{v},\ \mathbf{r} = (x_1, x_2, x_3),\ \mathbf{v} = (v_1, v_2, v_3). \quad (13.1.4)$$

University manuals usually recommend describing it with the help of the determinant

$$\mathbf{r}\times\mathbf{v}=\begin{vmatrix}\mathbf{l} & \mathbf{m} & \mathbf{n}\\ x_1 & x_2 & x_3\\ v_1 & v_2 & v_3\end{vmatrix}. \tag{13.1.5}$$

Let us note that the manuals recommended to use polar vectors $\mathbf{i}, \mathbf{j}, \mathbf{k}$ in (13.1.5) and not $\mathbf{l}, \mathbf{m}, \mathbf{n}$. We said above that such description was incorrect: the basis $\mathbf{i}, \mathbf{j}, \mathbf{k}$ leaves the movement in X but actually it takes place in Y. Therefore the basis $\mathbf{i}, \mathbf{j}, \mathbf{k}$ in (13.1.5) was changed for $\mathbf{l}, \mathbf{m}, \mathbf{n}$. But we are compelled to note that rotational movement can be described as a combination of vectors in $\mathbf{i}, \mathbf{j}, \mathbf{k}$, *i.e.*, without tensor usage. The movement (13.1.4) is usually understood as movement along a circumference. The movement (13.1.5) can be more conveniently described as action of antisymmetric tensor on $\mathbf{v}$:

$$B(\mathbf{v})=\begin{pmatrix}0 & -x_3 & x_2\\ x_3 & 0 & -x_1\\ -x_2 & x_1 & 0\end{pmatrix}\begin{pmatrix}v_1\\ v_2\\ v_3\end{pmatrix}, \tag{13.1.6}$$

describes rotation along the surface, *i.e.*, along the circle painted by the particle radius-vector. In other words, purely rotational movement in a certain sense has an intermediate character between movements in spaces X and Y. But in general we are not able to describe velocity (13.1.3) in terms of vectors in X.

Let us introduce new tensor

$$C=\begin{pmatrix}0 & x_3 & 0\\ 0 & 0 & x_1\\ x_2 & 0 & 0\end{pmatrix} \tag{13.1.7}$$

Velocity in Y can be described in the following way

$$\frac{d\mathbf{R}}{dt}=A(\mathbf{v})=B(\mathbf{v})+2C(\mathbf{v}) \tag{13.1.8}$$

The symmetric tensor A is described as a sum of antisymmetric tensor B describing rotation and a certain "addition" $2C$. The last tensor will be called interference: it imparts wave character to particles movement. Let us summarize everything we said above.

The following mathematical apparatus was proposed to describe Brownian and quantum-mechanical movement. In addition to traditional three-dimensional Euclidian space X the six-dimensional also Euclidian space Y is introduced. Coordinate planes of the initial space X play role of the axis in the new space. Smooth trajectories in Y are "seen" from X as rotational movement with interference. Let us consider two-dimensional movement to explain the last assertion. Let r and φ be polar coordinates on the plane. One obtains

$$x_3=0,\ x_1=r\cos\varphi,\ x_2=r\sin\varphi, \tag{13.1.9}$$

$$v_r=\frac{dr}{dt}=r',\ v_\varphi=r\frac{d\varphi}{dt}=r\omega, \tag{13.1.10}$$

$$\begin{aligned}v_1&=r'\cos\varphi-r\sin\varphi\varphi',\\ v_2&=r'\sin\varphi+r\cos\varphi\varphi'.\end{aligned} \tag{13.1.11}$$

Using tensor A one obtains movement with surfalinear velocity

$$\begin{aligned}(x_1v_2+x_2v_1)\mathbf{n}&=r(v_r\sin2\varphi+v_\varphi\cos2\varphi)\mathbf{n}=\\ &=(rr'\sin2\varphi-\varphi' r^2\cos2\varphi)\mathbf{n}.\end{aligned} \tag{13.1.12}$$

The axial vector n is a normal to the plane (X_1, X_2), $X=(X_1, X_2, X_3)$, X_i are axes of the space X.

Using tensor B one obtains

$$(x_1v_2-x_2v_1)\mathbf{n}=r^2\omega\mathbf{n} \tag{13.1.13}$$

Rotation (13.1.13) is similar to the second item in (13.1.12). But there is no uniform rotation in surfalinear movement. The multiplier $\cos 2\varphi$ makes such rotation rather similar to pendulum movement: when $\varphi\in[0,\pi/4)$ the particle moves decelerating into one direction, when $\varphi\in[\pi/4,\pi/2)$ it returns accelerating, when $\varphi\in[\pi/2,3\pi/2)$, it goes on decelerating. When $\varphi\in[3\pi/2,2\pi)$ it returns accelerating. Then the cycle repeats. The velocity of such movement is proportional to the square covered by radius-vector.

The first item in (13.1.12) is also pendulum like because of the sine multiplier. But its value is proportional, not to radius squared, but to the product of the radius and the velocity of its changing. Therefore this item is zero when the radius is stable.

The inquisitive reader can verify that the picture is qualitatively the same in the three-dimensional case, but is complicated by the additional angle in the spherical system of coordinates.

Surfalinear movement kinematics introduces a new type of phenomenon that explains at least some paradoxes in quantum mechanics. Surfalinear movement of the particle can apparently turn into curvilinear one, and vise-versa. All the causes that lead to changing surfalinear type of movement to trajectorian one must be clarified in the future. But here are some examples.

Light photons brush against the edges of a small screen and change their trajectorian movement for surfalinear one and lighten the center of its shade.

We cannot understand through which of the two apertures the electron penetrated because it changes its trajectorian movement for surfalinear, having collided with the whole edge, and we have lost the trajectory of its movement. But see we have explained this electron that has forced its way through the aperture with high frequency light and it again moves along a trajectory.

The uncertainty principle in quantum mechanics also becomes clearer. Let us compare purely rotational and surfalinear movement of an electron e. Let $\boldsymbol{\omega}$ be its angular velocity and $\mathbf{r}$ its rotational radius. The electron's rotational energy is

$$E_t=e\left|\mathbf{r}\times(\mathbf{r}\times\boldsymbol{\omega})\right|=er^2\omega \tag{13.1.14}$$

The energy of its surfalinear movement is

$$E_S=eR\omega. \tag{13.1.15}$$

And let the angular velocities for these two types of movements coincide. Thus we must compare only two values:

$$r^2=x_1^2+x_2^2+x_3^2 \tag{13.1.16}$$

and

$$R=\sqrt{(x_1x_2)^2+(x_2x_3)^2+(x_1x_3)^2}. \tag{13.1.17}$$

One obtains by squaring the two expressions:

$$r^4 = x_1^4 + x_2^4 + x_3^4 + 2x_1^2x_2^2 + 2x_2^2x_3^2 + 2x_1^2x_3^2 \geq R^2 =$$
$$= x_1^2x_2^2 + x_2^2x_3^2 + x_1^2x_3^2.$$

For the same reasons, for any particle of mass m moving with velocity v we obtain for its trajectorian angular momentum as

$$P_t = mvr = mr^2\omega \tag{13.1.18}$$

and its surfalinear impulse

$$P_S = mR\omega, \tag{13.1.19}$$

i.e.,

$$P_t > P_s. \tag{13.1.20}$$

In particular, for any surfalinear velocity T, such that

$$mT = \hbar \tag{13.1.21}$$

one obtains

$$mvr > mT = \hbar. \tag{13.1.22}$$

We can say that the uncertainty principle is valid because surfalinear movement is more energetically advantageous.

13.2. Mechanical Dimensions the Thermodynamic Variables

Surfalinear velocity has dimension m²/s. It reflects the fact that particle covers, not a line, but rather a surface in its movement. But do such movements exist in Nature?

A Brownian particle apparently moves surfalinearely [56]. Just because of this fact, observations show that its movement time is proportional, not to its path, but rather to its path square. We daresay that quantum paradoxes are also linked with the surfalinear type of the quantum particles movement.

But does not stochastic method solve the problem?

First, the probabilistic method is also used in a peculiar way. Not the mean, but the mean square is used to describe Brownian movement in order to take into consideration the square type dependence of the path from time.

But the main point is: "What does probabilistic description give us?" Does it increase our understanding of the objective side of reality?

In the courses for engineers, probability is usually defined as frequency limit. Of course, such a definition is unsatisfactory, as for the mathematician as for the engineer. The mathematician hears in such definition only the fact that a sequence converges to a limit. The words about a coin and its throwing remain only as an annoying noise.

The physicist does not see in it the principal point for him: "What is the physical cause for such convergence?"

Therefore, in the refined mathematical courses probability is described just as a continuous in empty set normalized measure on sigma-algebra of Borel or Lebeg subsets. The only thing left for a physicist is to understand probability as a measure of his misunderstanding.

We can say that probabilistic description is just a confession of our incapability to understand the essence of the processes we observe.

Let us try in this section to connect the concept of surfalinear velocity with physical facts for explanation of which probabilistic approach is used. Nowadays we shall base our investigation on a system of axioms-assumption from which theorems-conclusions will be obtained. We follow mathematical traditions here.

Assumption 1. Temperature T is actually just the surfalinear velocity of the particles or the thermodynamic wave.

This means that temperature has dimension m²/s. We shall see that thermodynamic fields also has dimension m²/s.

Let us consider the energy

$$E = kT. \tag{13.2.1}$$

Here k is the Boltzmann's constant for a separate particle. If T has dimension m²/s then k has dimension kg/s. The mechanical value of the electric charge is

$$e = 7.072 \times 10^{-10}\ \frac{\text{kg} \cdot \text{rad}}{\text{s}}. \tag{13.2.2}$$

Assumption 2. Boltzmann's constant is actually the electric charge, *i.e.*,

$$k = e = 7.1 \times 10^{-10}\frac{\text{kg} \cdot \text{rad}}{\text{s}} = 1.38 \times 10^{-23}\frac{\text{kg} \cdot \text{m}^2}{\text{s}^2 \cdot \text{K}}. \tag{13.2.3}$$

This equality enables us to find degree value in mechanical terms:

$$1\ \text{K} = 1.9523 \times 10^{-14}\frac{\text{m}^2}{\text{s} \cdot \text{rad}}. \tag{13.2.4}$$

Thus we can interpreter (13.2.1) energy as energy of electron's surfalinear movement.

The new understanding of temperature enables us to speak about the temperature of a separate particle, and not only about their ensemble, as it is now. Thus we can say about body temperature as about surfalinear velocity's nearness of the body particles and avoid the bulky construction which modern thermodynamics is compelled to use.

In the framework of the proposed approach, surfalinear velocity is a vector, or to be more accurate, a pseudovector. Today, thermodynamics understands temperature as a scalar, although it speaks about its spread. Therefore we shall also understand temperature as a scalar, *i.e.*, pseudovector's modulus. The same assertion is assumed valid for electric charge. The question appears if the proposed definition of temperature is equivalent to the traditional one nevertheless. Certainly not in general. As electric charge induces electric field with dimension of trajectorian velocity m/s, so also surfalinear movement of a particle induces a thermodynamic field with m²/s dimension.

An electric charge movement induces a wave with phase velocity. Electric charges ensemble movement with close velocities induces a wave with group velocity.

Today, determination of temperature tells us about group velocity of the thermodynamic wave. The introduced concept of temperature of a separate particle enables us to speak about temperature as the phase velocity of the thermodynamic wave.

The field approach helps us to understand the physical essence of the energy (13.2.1): this is the energy of the surfalinear

movement of electric charges. Let us consider this energy link with heat. We shall try to do this in mechanical terms.

Assumption 3. The thermodynamic field exists, and the thermodynamic impulse (mass and surfalinear velocity product) modulo equal to Planck's constant $\hbar$ is its charge. And heat is

$$Q=\hbar\omega. \tag{13.2.5}$$

In what follows we shall call $\omega = Q/\hbar$ specific thermodynamic heat.

In what aspect does the introduction of mechanical dimensions helps us? First of all, it clarifies the concept of temperature. Today it is believed necessary to separately introduce the so called "zero principle" in thermodynamics: the supposition about temperature's existence. But the physical essence of the temperature is not explained by the zero principle. The explanation of the essence is changed for accurate description of its measurement procedure.

Mechanical terms help us to understand temperature's essence and clarify the physical cause of the ergodic theorems validity: the particles having different surfalinear movements means they collide with each other. Therefore, temperature "flows" from more warm to less warm parts of the system. This process apparently just reflects movement of the ether particles.

We clarify the concept of temperature when we introduce the idea of surfalinear movement. Its measuring procedure can be left as it is now. Certainly in some time a technology to measure just surfalinear velocity must appear because now we can speak, not only about ensemble temperature, but also one particle temperature as well, which we cannot measure nowadays. But this characteristic also turns out to be important. We shall return to this problem soon when thermodynamic waves are considered.

If we are able to measure temperature, we can postpone the problem of its physical meaning for some time, having replaced the answer by its stochastic imitation.

But the problem with heat in modern physics is much more serious. When the idea of the caloric was rejected the heat concept turned to be suspended. Today heat is defined with the help of temperature, and this makes difficult to distinguish them. Degree is introduced into calorie definition; thus heat turns out to be just a linear function of the temperature and becomes undistinguishable from it.

When we understand energy (13.2.1) as electric charges movement and energy (13.2.5) as thermodynamic charges oscillating, we separate heat and temperature concepts and return to the ideas of Descartes and Newton, and caloric concept naturally changes for habitual for modern physics concept of field. But heat temperature and entropy turn to be frequency velocity and wave number of the thermodynamic wave. We come to field description of the thermodynamic problems.

13.3. The Thermodynamic Field

We plan to introduce the concept of the thermodynamic field in the way this concept appears in electrodynamics. Therefore we shall return to the electric field idea in the discourse, and some facts from electrodynamics will be recalled in the process.

A concept of wavenumber usually is introduced when a light wave with frequency v is moving with velocity c. Wave number is defined as angle module derivative with respect to radius

$$\left|\frac{d\varphi}{dr}\right|=k=\frac{v}{c}. \tag{13.3.1}$$

The problem of vector angle and angular velocity was already mentioned above. The situation in (13.3.1) is analogous, but the derivative is calculated with respect to r and not time. As a result, the gradient module is obtained, and only later is its vector (wave vector) introduced. The correlation (13.3.1) can be understood as the rotation angle per wavelength. It can be expressed in different ways:

$$\mu=\frac{2\pi}{k}, \tag{13.3.2}$$

$$v=ck. \tag{13.3.3}$$

Here μ is the light wavelength, c is the light velocity.

One obtains after differentiating (13.3.3)

$$dv=cdk+kdc. \tag{13.3.4}$$

If the light wave velocity is stable, the second item in (13.3.4) is zero and

$$dv=cdk. \tag{13.3.5}$$

Mechanical dimensions introduced earlier for thermodynamic values enable us to see that something similar is considered in the thermodynamics as well.

The connection between heat and temperature is considered as quasistatic process and usually formulated in the equity:

$$\delta Q=TdS. \tag{13.3.6}$$

Variation differential δ is used instead of the conventional differential in order to take into account that heat differential in traditional discourses is not total. Following that logic, we must write variation differential in (13.3.5) as well. But the field approach helps us to avoid this problem.

Let us introduce the thermodynamic wave concept as an analogue to light wave (13.3.3)

$$\omega=T_pL. \tag{13.3.7}$$

Here ω is the heat, T_p is the temperature, *i.e.*, phase surfalinear velocity of the thermodynamic wave created by a separate particle, $L=S/\hbar$ is specific entropy, *i.e.*, wave number of the thermodynamic wave.

One obtains after differentiating (13.3.7)

$$d\omega=LdT_p+T_pdL. \tag{13.3.8}$$

We start from (13.3.8) and understand entropy as wave number of the thermodynamic wave. Sometimes we shall use the concept of the thermodynamic wave square, the idea analogous to light wavelength

$$\lambda=\frac{\pi}{L}\left[\frac{\text{m}^2}{\text{rad}^2}\right], \tag{13.3.9}$$

$$L = \frac{\pi}{\lambda}\left[\frac{\text{rad}^2}{\text{m}^2}\right]. \tag{13.3.10}$$

Index p in the temperature (thermodynamic wave velocity) T in (13.3.8) underlines that we speak about phase velocity of the wave induced by a separate particle.

In electrodynamics we often consider group velocity in addition to phase velocity. Group velocity is induced by charges oscillating with close frequencies and correspondingly close wave numbers. The velocity of such a group wave packet is defined, not by correlation (13.3.3), but by the derivative

$$\frac{dv}{dk} = g. \tag{13.3.11}$$

Repeating the similar discourse we can also speak, not about phase temperature T_p, but about group temperature T defined by the derivative

$$\frac{d\omega}{dL} = T. \tag{13.3.12}$$

It is especially important to consider this case because the concept of temperature adopted in today's physics is actually based on the idea of just group packet.

The phase velocity of the light wave can depend, or not depend, on the wave number. This depends on the medium in which the wave propagates.

In the second case (not depend), packet velocity coincides with phase velocity. In the first case, it can be either bigger or less than the phase one. The same situation takes place in thermodynamics. Really, differentiating (13.3.7) with respect to L one obtains in the second case

$$T = \frac{d\omega}{dL} = \frac{d(T_p L)}{dL} = T_p. \tag{13.3.13}$$

Group and phase velocities coincide.

One obtains in the first case

$$T = \frac{d\omega}{dL} = T_p + L\frac{dT_p}{dL}. \tag{13.3.14}$$

T value depends on the sign of the second item.

Let us rewrite (13.3.13) and (13.3.14):

$$d\omega = T_p dL, \tag{13.3.13a}$$

$$d\omega = T_p dL + L dT_p. \tag{13.3.14b}$$

Equality (13.3.6), which is actually entropy's definition, means that temperature does not depend on entropy. Therefore the circle integral in the left hand and right hand parts in (13.3.6) will be equal to zero only under additional condition that the process is quasistatic.

And what does take place in non-static processes?

From today's point of view, entropy will increase. From the thermofield point of view the second item in (13.3.14*a*) will "begin working".

Let us discuss this problem in greater detail.

13.4. What is Entropy?

The entropy definition (13.3.6) is actually based on the equality (13.3.13*a*). *i.e.*, it uses the temperature concept as phase velocity of the thermodynamic wave. But today's adopted temperature definition demands consideration of just group velocity. Experiments showing this discrepancy led to the necessity to use variation differential in the left hand part in (13.3.6). It is believed that we take into account the whole trajectory of the process and not only local characteristics in this way. The field description of the process removes this problem. Introduction of mechanical dimensions for temperature and heat enables us to throw a new look at the problem of entropy increasing.

Let us begin with the famous formula of entropy increment

$$\Delta S = k \ln\left(\frac{V_2}{V_1}\right). \tag{13.4.1}$$

One obtains it when analyzing free isothermal extension of the ideal gas from volume V_1 to volume V_2. Today the volume enlargement is interpreted as disorder increase in the particle's disposition. This chaos is described with probabilistic characteristics, and often the "chaos measure" W appears instead of the (V_2/V_1) fraction.

It was assumed above that Boltzmann's constant k was actually electric charge with dimension kg/s. This means that the value L in the left hand part of (13.4.1) actually has dimension of electric charge, and not entropy. We can easily correct it because the very equity is valid. One obtains dividing both parts of (13.4.1) by $\hbar$:

$$\Delta L = L_0 \ln\left(\frac{V_2}{V_1}\right), \tag{13.4.2}$$

here $\Delta L = \frac{\Delta S}{\hbar}$, $L_0 = \frac{k}{\hbar}$.

Constant L_0 can be interpreted as "elementary" ether (physical vacuum) entropy. It will appear once more when we come to the analyses of black body radiation. One can say that L here is the wave number for ethereal waves. It increases as the logarithm of the volume contained in the surface covered by the surfalinear wave. The conclusion is: correlations (13.4.1) and (13.4.2) are consequences of the ether qualities, and not of the gas.

In other terms, ether particles behave as molecules of an ideal gas. And real gases' behavior is just a sum of the ideal gas movement and the movement determined by special qualities of the gases. Gas thermometers' observations supply us with an additional confirmation for this point of view. When ideal gas is used in a gas thermometer, the ratio of the water boiling and freezing points, T_S/T_i, is equal to the corresponding fraction for the pressures, p_s/p_i, and is equal to 1.36605 for any pressures p_s and p_i. But for the real gases this is valid only if $p_i \to 0$, *i.e.*, if the real gas' particles actually disappear. And what is left? The ether remains.

Let us consider an additional correlations between values whose essence are close to entropy. I mean specific heat capacity under stable pressure and stable volume.

If specific entropy is $\delta\omega/T$, then specific heat capacity under stable pressure is

$$c_p = \hbar\left(\frac{\delta\omega}{dT}\right)_p, \tag{13.4.3}$$

and specific heat capacity under stable volume is

$$c_V = \hbar\left(\frac{\delta\omega}{dT}\right)_V. \tag{13.4.4}$$

The difference between them and the entropy is approximately the same as between wave number when we speak about group velocity (specific heat capacity) and when we speak about phase velocity (entropy). Therefore in modern theory entropy turns out to be a total differential and specific heat capacity depends on the process (stable pressure, stable volume, *etc*.).

A certain correlation is found for the heat capacities:

$$c_p - c_V = k.$$

Here k is again Boltzmann's constant. And again we are compelled, in order to adjust dimensions, to divide the right hand part in (13.4.3) by thermodynamic charge $\hbar$. One obtains

$$\frac{c_p - c_V}{\hbar} = \frac{k}{\hbar} = L^*. \tag{13.4.5}$$

We see that again we speak about an ideal gas. The specific entropy increment because of volume increment in this case is defined by equality (13.4.2):

$$\frac{\Delta c_V}{\hbar} = L^* \ln\left(\frac{V_2}{V_1}\right). \tag{13.4.6}$$

Now we can express specific heat capacity increment when pressure is stable:

$$L = \frac{\Delta c_p}{\hbar} = L^*\left(1 + \ln\left(\frac{V_2}{V_1}\right)\right). \tag{13.4.7}$$

Thus specific heat capacity when pressure and volume are stable is just elementary specific entropy. The increment takes place because of volume increases.

It becomes clear why this correlation is accurately valid only for ideal gas: there is more electric charges k in non-ideal gases, and ether characteristics in fluids and rigid bodies essentially differ from free ether characteristics.

And what is specific entropy? It is just wave number of the thermodynamic wave. The new understanding includes the traditional one as a special case. It becomes clear that we cannot interpret entropy as a chaos measure.

13.5. The Second Law of Thermodynamics.

The equality (13.3.13*a*) asserts that today entropy is understood as wave number for phase thermodynamic velocity. In the experiments temperature is always understood as group velocity (13.3.14*a*). In other terms, the assertion about entropy increasing is the consequence of the second item in (13.3.14*a*) not being taken into account in modern physics.

Let us introduce the concept of anomalous dispersion for thermodynamic wave ($LdT < 0$, phase velocity is bigger than the group one, entropy decreases) and normal dispersion ($LdT > 0$, phase velocity is less than the group one, entropy increases).

The same situation is observed in a light wave. But our definition is in a certain sense symmetric to the case of the electric field. There normal dispersion term is used when phase velocity is bigger than the group one and term anomalous is used when phase velocity is less than the group one. Our definition was determined by the tradition when increasing entropy is considered normal because the majority of experiments show increasing entropy.

But do opposite experiments exist? Yes, they do. Many experiments on nuclear magnetic resonance show unexpected results. Today such states are interpreted as states with negative temperature. Let us consider these important experiments with greater accuracy.

In 1951 Purcell and Pound produced experiments showing that atomic and nuclear magnetic moments, which follow the external magnetic field under low temperature, change this line for the opposite (see [42], [44]) when temperature is very high. This could be explained if the temperature in the entropy definition were negative. Perhaps because of this very strange concept that a domain of negative temperature begins behind infinitely big positive temperature, it is assumed now that under negative temperature the second principle of the thermodynamics changes its sign: we cannot convert work into heat without compensation under negative temperature. Certainly such construction seems strange. Note that infinitely big temperature was certainly not overcome in the experiment, but the effect took place.

In the section devoted to black body radiation it will be shown that temperature T_0 equal approximately to 10^9 degrees exists in the thermodynamic field. This temperature plays the role of light velocity in thermodynamics. When an isothermal process takes place with temperature higher than T_0 the sign in the second principle changes and anomalous dispersion appears. Let us try to understand the field because that leads to the appearance of anomalous dispersion. Let us multiply both sides of the equity (13.3.7) by thermodynamic charge $\hbar$. One obtains

$$\hbar\omega = \hbar TL. \tag{13.5.1}$$

The left hand side here is the heat energy that can be transferred without losses as into energy of the surfalinear movement of electric charges kT (13.2.1) as in mechanic energy. In other terms, the coefficient is stable under such a transformation.

Expression $\hbar T$ in the right hand part can be considered as quite a new type of energy. This is energy of thermodynamic charges' surfalinear movement. We shall call it thermodynamic energy. Its dimension kg·m^4/s^2 differs from the habitual one and coefficient L (specific entropy) which determines such translation varies. The second thermodynamic principle is indebted for its existence to just this type of energy. One can also say that $\hbar T$ is the energy of the thermodynamic wave induced by the thermodynamic charges' movement. In order to obtain mechanic energy from it, we must previously transfer it into heat energy,

the energy of thermodynamic charges' oscillations. But when the process phase temperature is lower than the group temperature, it is linked with entropy increase and consequently losses (compensation). Just because of this the condenser appears in the Carnot cycle. Thermodynamic energy $\hbar T$ translates into heat energy $\hbar\omega$ and energy losses (compensation) take place in it.

Let us consider the following cycle process similar to the Carnot cycle.

Let us begin with the adiabatic step. In accord with its definition, heat changes do not take place in adiabatic processes. One obtains from field equation (13.3.14*a*):

$$d\omega = T_p dL + L dT_p = 0. \tag{13.5.2}$$

The heat increment is zero.

This is an equation with separable variables. Its solution is:

$$LT_p = L_0 T_p^0, \tag{13.5.3}$$

Here L_0, T_p^0 are initial conditions.

Thus we neither obtain additional work nor loose it because temperature increase can take place only at the cost of entropy decrease and symmetrically.

Of course we could come to this conclusion already without calculations: just heat can be translated into work without losses but its quantity does not change.

This means that compensation (losses in the process of translating into work) takes place at the isothermal step.

For this step equation (13.3.14) looks as follows: thermodynamic wave group velocity (traditionally understood temperature)

$$T = T_p + L\frac{dT_p}{dL} = c_1 = \text{const}. \tag{13.5.4}$$

This is a linear differential equation. Its solution is

$$T_p = \frac{c_2}{L} + c_1 \tag{13.5.5}$$

or

$$L(T_p - c_1) = c_2. \tag{13.5.6}$$

Let us substitute temperature (13.5.5) into (13.3.14*a*).

$$d\omega = \frac{c_2 + c_1 L}{L} dL. \tag{13.5.7}$$

If $d\omega > 0$ then we obtain work, if $d\omega < 0$ we lose it, if $d\omega > 0$ the process is balanced. Just this last case is usually considered in the thermodynamics. Equation (13.5.6) yields that we can reach equilibrium if

$$T_p = c_1. \tag{13.5.8}$$

And what is temperature c_1? This is the thermodynamic wave group velocity in the medium in which the experiment takes place. In the case of free ether, this is temperature T_0. Its value will be found in the next section. In general it will be denoted as T_g. If

$$T_p > T_g, \tag{13.5.9}$$

entropy S must decrease, when T_p increases in order to preserve equality (13.5.6). If

$$T_p < T_g, \tag{13.5.10}$$

the entropy must increase.

If S is stable the heat c_2 can be interpreted as the heat necessary for T_p to reach T_g. The very essential conclusion from consideration of the Carnot cycle is the assertion that its efficiency cannot overcome 1. Let us understand this assertion from the wave point of view. Let us start from the heat

$$\omega_1 = L_1 T_1^p \tag{13.5.11}$$

and adiabatically translate it into $S_2 T_2^p$ state. We cannot obtain any heat in addition, *i.e.,*

$$\omega_1 = L_2 T_2^p. \tag{13.5.12}$$

if $T_2^p > T_1^p$, then $L_2 < L_1$, and symmetrically.

At the second step we translate the process isotermically into state

$$\omega_2 = L_3\left(T_2^p - T_g\right) = \omega_1 + c_2. \tag{13.5.13}$$

At the third step we adiabatically translate to the state with the initial temperature T_1. This takes place with specific entropy L_4. One obtains

$$L_3\left(T_2^p - T_g\right) = L_4 T_1^p = \omega_1 + c_2. \tag{13.5.14}$$

From here

$$\frac{L_4}{L_3} = \frac{T_2^p - T_g}{T_1^p}. \tag{13.5.15}$$

The right hand part here is interpreted as losses in the process of going from temperature T_1^p to T_2^p and returning to T_1^p. Until $T_2^p < T_g$ it is negative (losses). If $T_2^p > T_g$ it is positive (profit). Physically this means that if $T_2^p < T_g$ the thermodynamic energy is translated into work with losses (compensation). In the opposite case, it is translated into work with surplus (decompensation).

We started from the heat

$$\omega_1 = L_1 T_1^p, \tag{13.5.16}$$

and returned to temperature T_1^p with the heat

$$\omega_1 + c_2 = L_4 T_1^p. \tag{13.5.17}$$

i.e.,

$$L_4 - L_1 = \frac{c_2}{T_1^p}. \tag{13.5.18}$$

The entropy difference decreases with T_1^p increase. It becomes zero (the process is equilibrium) when T_1^p reaches T_g. If T_g is

overcome this difference becomes negative (the initial entropy of the cyclic process is bigger than the final one).

13.6. Absolute Black Body Radiation

The existence of the two types of energy considered above plays an important role in a problem that was determining the face of physics for many decades. This is heat energy of the thermodynamic charges' oscillation, $\hbar\omega$, and electric charges' surfalinear movement, kT. They both appear in the Plank formula describing spectral brightness of the black body radiation.

$$f_\omega = \frac{\omega^2}{4\pi^2 c^2}\frac{\hbar\omega}{\exp\left\{\frac{\hbar\omega}{kT}\right\}-1}. \quad (13.6.1)$$

Let us remind some facts about the electron. It has a toroidal structure. It is assumed that the ether particles drawing the torus perform two movements. Rotation of the quarter circumference creating the torus determines electric charge and rotation of the smaller circumference determines thermodynamic charge $\hbar$.

The radius of the greater circumference

$$r_0 = 3.8616\times10^{-13} \text{ m}. \quad (13.6.2)$$

Surface of the circle covered by the greater torus circumference radius is

$$\pi r_0^2 = 4.6847\times10^{-25} \text{ m}^2. \quad (13.6.3)$$

The radius square r_0^2 is designated as λ_0 and is called thermodynamic wave square. Thus the entropy (wave number) is defined by the equality

$$L_0 = \frac{1}{\lambda_0} = 6.7061\times10^{24}\ \frac{\text{rad}}{\text{m}^2}. \quad (13.6.4)$$

The angular velocity of the greater circumference radius rotation in the electron torus is

$$\omega_0 = 7.7634\times10^{20}\ \frac{\text{rad}}{\text{s}}. \quad (13.6.5)$$

This coincides with the Compton angular velocity for the electron.

The electron's mass is taken from experiment

$$m_e = 9.1094\times10^{-31} \text{ kg}, \quad (13.6.6)$$

and the electron's charge

$$m_e\omega_0 = 7.072\times10^{-10}\ \frac{\text{kg}}{\text{s}}. \quad (13.6.7)$$

We have already met this value above.

Let us note that

$$r_0\omega_0 = c,\ c^2 = \lambda_0\omega_0^2, \quad (13.6.8)$$

where c is light velocity in free ether. Thermodynamic charge

$$\hbar = \lambda_0\omega_0 m_e = 1.045\times10^{-34}\ \frac{\text{kg}\cdot\text{m}^2}{\text{s}}. \quad (13.6.9)$$

Let us note that the lesser circumference radius is 2 times less than the greater one, but its angular velocity is 2 times bigger. Thus electron's spin is $\hbar/2$.

Taking all these facts into account in (13.6.1) one obtains

$$f_{\omega,L} = \frac{\omega^3 L_0}{4\pi^2\omega_0^2}\frac{\hbar}{\exp\left\{\frac{L}{L_0}\right\}-1}. \quad (13.6.10)$$

Here $L = \omega/T$ is specific entropy of the thermodynamic wave, $L_0 = \omega_0/T_0$.

Temperature T_0 plays the same role in the wave thermodynamics that light velocity plays in electrodynamics.

$$T_0 = \frac{\omega_0}{L_0} = 1.147\times10^{-4}\ \frac{\text{m}^2}{\text{s}\cdot\text{rad}} = 5.9299\times10^9 \text{ K}. \quad (13.6.11)$$

Just when this boundary is overcome the effects changing sign in the second thermodynamic principle appear. Just these effects led to the idea of negative temperature, which allegedly begins after infinitely big positive temperature. We said this above.

Formula (13.6.10) is the consequence of the thermodynamic wave (13.3.7) concept. It clarifies physical essence of the fraction $\hbar\omega/kT$. This is the entropy fraction in the framework of the field idea, *i.e.*, entropy is defined for any frequency (heat) ω and any surfalinear velocity (temperature) T_p, induced by any particle. In other words, phase surfalinear velocity, and not group velocity, *i.e.*, temperature as it is understood today. In the Plank formula group velocity (habitual temperature) can appear only as the mean after integrating I_ω over ω. Thus when Plank spoke about discrete energies, it had to mean separate thermodynamic charges oscillation, and not electric ones. The electrodynamic interpretation essentially hindered understanding of his formula. Therefore it is necessary to stress that (13.6.10) formula describes radiation of the thermodynamic and not electric field. And therefore it was so difficult for Plank to explain the experimental fact by electric charge oscillations. Therefore he was compelled to assume the discrete character of energy, which is not seen in his formula. Actually, the thermodynamic charges oscillate and the electric charges move with surfalinear velocity T_p. Just their ratio leads to disappearing of ultraviolet catastrophe. And entropy unites the very processes.

The heat ω in (13.6.10) can be expressed with the help of temperature and entropy. One obtains

$$f_{S,T} = \frac{T^3 L^3}{4\pi^2 T_0^2 L_0}\frac{\hbar}{\exp\left\{\frac{L}{L_0}\right\}-1}. \quad (13.6.12)$$

Sometimes the formula (13.6.1) is translated from light frequency to wavelength using (13.3.2) correlation. The discussion above means that such translation is not correct. It is possible to come from frequency-entropy form (13.6.10) to temperature-square form using correlation (13.3.7) and (13.6.4). One obtains

$$f_{\lambda,T} = \frac{T^3\lambda_0}{4\pi^2 T_0^2 \lambda^3} \frac{\hbar}{\exp\left\{\frac{\lambda_0}{\lambda}\right\} - 1}. \tag{13.6.13}$$

But λ here is not the light wavelength but the square of the thermodynamic wave velocity, T is radiation temperature.

It is also not correct to translate from the Wien formula

$$f_{\omega,T} = \omega^3 F\left(\frac{\omega}{T}\right) \tag{13.6.14}$$

to light wavelength dependence

$$\mu = \frac{c}{\omega} \tag{13.6.15}$$

when the "extreme formula" called Wein displacement formula

$$\mu_{\max} T = \text{const} \tag{13.6.16}$$

is obtained.

The most important problem that appeared when black body radiation was investigated is incomplete translation of the internal energy of the heated body into equilibrium radiation: the greater part of energy was conserved inside. Just this problem led to the necessity to deny traditional mechanics.

The field point of view is not to deny classic mechanics, but to supplement it with the concept of surfalinear movement.

The internal energy of a heated body is the thermodynamic energy of the thermodynamic charges' surfalinear movement $\hbar T$. Its dimension is kg·m²/s². Translation to habitual type of energies with dimension kg·m²/s² is determined by entropy and heat changes (13.6.10), or do the same by temperature and thermodynamic wave square (13.6.13).

Eqs. (13.6.10) and (13.6.13) actually define the conditions under which translation of the thermodynamic energy into traditional one and *vice-versa* bakes place without losses (without compensation), *i.e.*, the process is equilibrium. The future exchange does not take place because the process must become non-equilibrium for this. And this would contradict to the first principle.

13.7. Gibbs Paradox

Let us consider Gibbs' paradox in field terms. In [42] the paradox is explained in the following way. "Entropy of two ideal gases' mixture is equal these gases' sum entropy when each gas occupies separately the same volume as the whole mixture under the mixture temperature." The authors in [42] starts from traditional logarithmic dependence on temperature T and volume V and obtain for the mixture of 1 mole of gas 1 and 1 mole of gas 2 the value of their mixture increment

$$\Delta S = 2kN \ln 2, \tag{13.7.1}$$

where k is Boltzmann constant and N is Avogadro number.

The paradox is seen in the fact that entropy increment of two ideal gases depend on their nature. It is believed that when two identical gases are mixed entropy does not increase because thermodynamic process does not take place when separating plate is removed.

Thus two identic gas mixtures cannot be understood as the limit of two different gases mixture. From the field point of view the fact that entropy in (13.7.1) is doubled is understandable: the number of particles is doubled. And just ideal gas particles are the support of entropy doubling but logarithm in (13.7.1) induces questions.

We obtain in the framework of field approach for two different types of ideal gases:

$$Q_1 = N_1 S_0 T_1, \tag{13.7.2}$$

$$Q_2 = N_2 S_0 T_2. \tag{13.7.3}$$

If $T_1 = T_2 = T$, $N_1 = N_2 = N$ (two ideal gases under the same temperature)

$$Q_1 + Q_2 = 2NS_0 T \Rightarrow \frac{Q_1 + Q_2}{NT} = S_0 + S_0 = 2S_0, \tag{13.7.4}$$

$$Q_1 - Q_2 = 0 \Rightarrow \frac{Q_1 - Q_2}{NT} = S_0 - S_0 = \Delta S = 0. \tag{13.7.5}$$

The problem in (13.7.1) is in the ln2 not in doubling N. The physical meaning of this result is the following today thermodynamics links entropy with disposition of particles and believes impossible to prescribe this quality to one particle.

The field approach yields that moving particle induces thermodynamic wave and identifies thermodynamic qualities of the particle with calorie, temperature and entropy of this wave. In the case of ideal gas the thermodynamic wave created by a set of particles is equal to sum entropy.

14. The Cycles of the Thermodynamic Field

14.1. Introduction

Deductions following from Carnot cycle have become an essential obstacle for engineers in their activity to optimize work of different heat engines. The field sight to thermodynamics proposed in previous paragraph has shown necessity of re-estimation and other understanding of some thermodynamic problems and quantum mechanics. The idea to revise analysis of the Carnot cycle naturally appears. What do we see *a priori*?

Although the whole analysis is devoted to heat the main conclusion is efficiency formula containing only initial and final temperature.

When the problem is analyzed with greater accuracy one sees that the root of the problem lies deeper in the history of the thermodynamics. In the period of the thermodynamics origin as a science interaction between three concepts was considered: heat which was linked with concept of the calorie, temperature which was associated with feeling of "hot–cold" and a coefficient which

connects heat and temperature. This coefficient was called entropy. It had become clear later that the idea of calorie did not fit some experiments. Instead reanalyzing the idea and accepting new concept of calorie it was buried completely although many experiments were in good accord with it and equations formulated on its basis are widely used today. Well known heat conductivity equation in partial derivatives can be an example.

An additional difficulty burdened this problem. Gas was usually used in experiment. And abstract notion of heat energy was linked with gas characteristics:

$$w = pV. \tag{14.1.1}$$

Here w is heat energy, p is pressure and V is volume. It seems that it follows just from (14.1.1) that heat differential must be total

$$dw = pdV + Vdp. \tag{14.1.2}$$

But only the first item in (14.1.2) was usually taken into account in experiments. Therefore and on some other historic reason the heat energy was considered a nonlocal function and they began writing variational differential δw instead total dw to take this into account.

Apparently this problem was inherited after more ancient problem hindering mechanical investigations up till now.

Although work in mechanics is defined as force and path product

$$A = \mathbf{F} \cdot \mathbf{l}, \tag{14.1.1a}$$

where A is work, $\mathbf{F}$ is force and $\mathbf{l}$ is path, the work increase is defined as force and path increase product

$$\delta A = \mathbf{F} \cdot d\mathbf{l}. \tag{14.1.2a}$$

But it is clear that reasonable definition must be

$$dA = \mathbf{F} \cdot d\mathbf{l} + \mathbf{l} \cdot d\mathbf{F}. \tag{14.1.2b}$$

dA is a total differential.

The situation with temperature turned to be somehow better. The third principle of thermodynamics was adopted. It axiomatically declared temperature existence. Very accurate procedure of its measurement was determined. The situation was accepted satisfactory in accordance with the idea: if we are able to measure this means that we understand the essence of the measured object.

The heat is defined as linear function of temperature in today physics. But how nonlocal function heat energy w can be a linear function of ordinary function temperature? One can observe that heat conductivity equation is often named temperature conductivity equation in scientific literature. But in accordance with the above adopted definition this is possible only if entropy is constant, *i.e.*, in equilibrium processes. Therefore when entropy is defined as

$$dS = \frac{\delta Q}{T}, \tag{14.1.3}$$

where δQ is variational differential, T is temperature and dS is local entropy differential the situation is completely muddled.

See we even cannot put thermodynamic problem. We need three independent definition for it: heat, temperature and entropy. But the first two notions are linked and entropy turns to be only temperature linear function. This means that any process is equilibrium, *i.e.*, entropy is constant. The second principle of thermodynamics turns to be needless.

Let us remind the facts that were proposed in previous paragraph.

Let us say that a process is naturally isothermal, if Eq.

$$\omega = T_g L, \tag{14.1.4}$$

is valid for it. Here ω is field heat, L is field entropy, T_g = const is group velocity of thermodynamic wave (group temperature).

Condition of T_g stability actually means that the whole heat transferred to the field is spent for entropy increase. And symmetrically: the heat taken away from the field decreases only entropy. The characteristic example is water evaporating and vice-versa. This means that T_g actually characterizes the medium in which the process takes place or to be more accurate the boundary between different states of this medium. But before evaporating water is being heated for some time, *i.e.*, phase velocity of the thermodynamic waves induced by water particles changes.

Group and phase velocities are connected by the equality

$$T_g = T + L\frac{dT}{dL}. \tag{14.1.5}$$

One can see that phase velocity T depends on entropy. Eq. (14.1.5) solution is

$$T = T_g + \frac{\nu}{L}, \tag{14.1.6}$$

where ν is a constant characterizing the process. It has dimension of heat. Because T depends on entropy it is necessary to use thermostat in order to keep temperature stable. The thermostat increases ν in (14.1.6) and compensates entropy increasing keeping T stable. Let us rewrite (14.1.6) in another form

$$L(T - T_g) = \nu. \tag{14.1.7}$$

$L > 0$, therefore when $T < T_g$, ν is negative, the process needs additional energy. If $T > T_g$, then ν is positive, the field extracts energy until medium has changed its structure (water has become vapor). If the structure has changed (water has become vapor) T_g increases up to a new value when new restructuration begins. (14.1.7) means that when $T = T_g$ then ν becomes zero: there is neither energy absorption no extraction.

Thus if entropy is fixed in isothermal process we always loose except the case $T = T_g$.

But in reality entropy changes in the process. Let it has changed from S_2 to S_3, *i.e.*, the heat has also changed from ν_2 to ν_3. Thus instead (14.1.7) one obtains

$$(L_2 - L_3)(T - T_g) = \nu_2 - \nu_3. \tag{14.1.8}$$

We assume that

$$T \le T_g. \tag{14.1.9}$$

This yields that if $L_3 > L_2$ then $\nu_2 > \nu_3$, *i.e.*, $(\nu_2 - \nu_3) > 0$. When entropy is increased our expenditures for the field decrease. In the opposite case $(\nu_2 - \nu_3) < 0$, *i.e.*, decreasing entropy we increase our expenditures for the field.

14.2. Thermodynamic Field Cycles

Field concept let us consider thermodynamic cycles in field terms. We shall consider field analog of the Carnot cycle.

It is known that Carnot cycle consists of four parts: two adiabatic and two isothermal ones.

Let us consider its field analog on fig. 14.2.1.

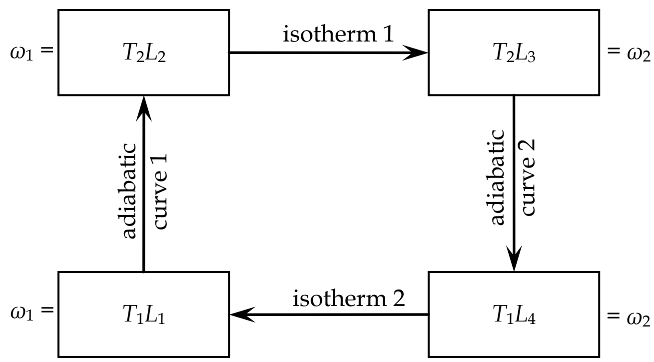


Fig. 14.2.1. Field Cycle.

We start from state with heat ω_1, *i.e.*, in accordance with (14.1.1) from temperature T_1 and entropy L_1. We transmit this state adiabatically into state T_2S_2. In accordance with adiabatic process definition we stay with the same heat ω_1, but temperature and entropy change. For simplicity we adopt that $T_2 > T_1$, *i.e.*, temperature is increased. Of course we could do this only decreasing entropy, *i.e.*, S_2 must be less S_1, $L_2 < L_1$.

Our second step is to isothermally go to another heat state

$$\omega_2 = T_2 L_3. \tag{14.2.1}$$

The temperature is stable in the process but entropy has changed (has become S_3). Correspondingly the heat has become

$$\omega_2 \neq \omega_1. \tag{14.2.2}$$

At the third step we adiabatically return to temperature T_1. Entropy also changes and becomes equal to L_4. But the heat remains stable and equal to ω_2. In order to conclude the process we must isothermally change L_4 for L_1 keeping temperature equal to T_1. Let us try to understand what we have obtained and what we have lost in the cycle.

Let us return to the isothermal process 1.

Heat change is described by Eq. (14.1.8): in order heat increment was positive, $((v_2 - v_3) > 0)$, entropy increment must be negative: $(L_2 - L_3) < 0$, *i.e.*, $L_3 > L_2$. This fact observation in experiments yielded conclusion: entropy always increases.

Let us return to the second isothermal process.

$$(L_4 - L_1)(T_1 - T_g) = \nu_4 - \nu_1. \tag{14.2.3}$$

If $(S_4 - S_1) < 0$ (entropy in the process increases) then $(\nu_4 - \nu_1) > 0$ (the heat decreases) and symmetrically.

There are connections between entropies in the two isothermal processes:

$$L_1 = \frac{T_2 L_2}{T_1}, \quad L_4 = \frac{T_2 L_3}{T_1}. \tag{14.2.4}$$

Thus (14.2.3) can be rewritten

$$\begin{aligned} &(L_4 - L_1)(T_1 - T_g) = -\frac{T_2}{T_1}(L_2 - L_3)(T_1 - T_g) < 0, \\ &i.e.,\ S_4 > S_1. \end{aligned} \tag{14.2.5}$$

Thus our losses for the field in the second isothermal process are bigger than on the first one because entropy in the process decreases. Let us say this in other way. We lose less in the first process because heat losses velocity decreases with entropy increase. The picture is symmetric in the second isothermal process. Let us compare losses velocity (14.2.5) with losses' velocity in the first process:

$$(L_2 - L_3)(T_2 - T_g) > 0. \tag{14.2.6}$$

One obtains the total losses change in two processes summing (14.2.5) and (14.2.6):

$$\begin{aligned} æ &= (L_2 - L_3)(T_2 - T_g) - \frac{T_2}{T_1}(L_2 - L_3)(T_1 - T_g) = \\ &= (L_2 - L_3)T_g\left[\frac{T_2 - T_1}{T_1}\right]. \end{aligned} \tag{14.2.7}$$

Certainly instead of (14.2.4) we could write

$$L_2 = \frac{L_1 T_1}{T_2}, \quad L_3 = \frac{L_4 T_1}{T_2}. \tag{14.2.4a}$$

and obtain instead of (14.2.5)

$$(L_2 - L_3)(T_2 - T_g) = -\frac{T_1}{T_2}(L_4 - L_1)(T_2 - T_g). \tag{14.2.5a}$$

and instead of (14.2.7) another expression for

$$\begin{aligned} æ &= (L_4 - L_1)(T_1 - T_g) - \frac{T_1}{T_2}(L_4 - L_1)(T_2 - T_g) = \\ &= (L_4 - L_1)T_g\left[\frac{T_1 - T_2}{T_2}\right]. \end{aligned} \tag{14.2.7a}$$

In (14.2.7) æ is expressed in terms of the first isothermal process and in (14.2.7*a*) it is expressed in terms of the second isothermal process. æ has dimension of heat and æ is always negative. This index characterizes inevitable energy losses in the cycle.

Let us consider reverse cycle (fig. 14.2.2). One obtains just as in the direct cycle

$$æ = (L_1 - L_4)T_g\left[\frac{T_2 - T_1}{T_1}\right] > 0. \tag{14.2.7b}$$

Thus the considered cycle is reversible, æ has become positive.

We started from ω_1 heat and came to ω_2. $(\omega_2 - \omega_1)$ is the heat participating in the cycle. It was obtained by the working body from external medium. The heat æ is the inevitable losses absorbed by the field. Losses coefficient is

$$\theta = \frac{|æ|}{\omega_2 - \omega_1}. \tag{14.2.8}$$

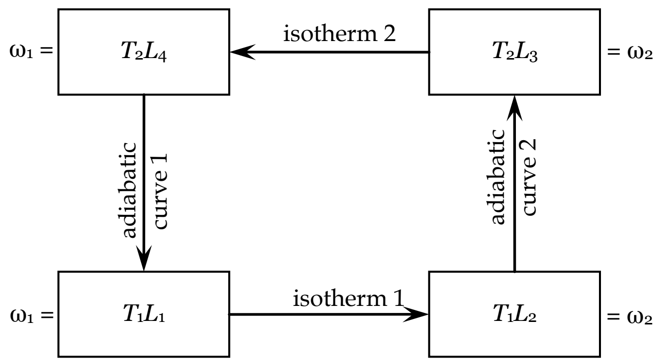


Fig. 14.2.2. Reverse Cycle.

One obtains from the first isothermal process

$$\theta = \frac{(L_2 - L_3)T_g(T_2 - T_1)}{T_1T_2(L_2 - L_3)} = \frac{T_g(T_2 - T_1)}{T_1T_2} = \frac{T_g}{T_1}\left[\frac{(T_2 - T_1)}{T_2}\right]. \quad (14.2.9)$$

θ characterizes ratio of the heat transmitted to the field to total energy. We isolated expression characterizing Carnot cycle in square brackets in order to distinguish our formula from the traditional one. Coefficient before the square bracket exceeds 1, *i.e.*, the whole expression can be bigger 1 as well. If so the following inequality holds

$$T_g \geq \frac{T_1T_2}{(T_2 - T_1)}. \quad (14.2.10)$$

The analyses of the partial derivatives show that right hand expression in (14.2.10) is increasing function of T_1 and decreasing function of T_2. This means that we must find medium with minimal boundary temperature for which inequality (14.2.10) holds. Thus we must take $T_2 = T_g$ and T_1 which is minimal for this medium. For instance for water $T_2 = T_g = 373°$, $T_1 = 273°$. One obtains

$$\frac{T_1T_2}{(T_2 - T_1)} = \frac{373 \cdot 273}{100} > 373. \quad (14.2.11)$$

Thus it is impossible for the processes with water to exceed 1. Bud do such media exist at all?

Let us simplify condition (14.2.10), *i.e.*: let $T_2 = T_g^{max}$, $T_1 = T_g^{min}$, where T_g^{max} is the upper and T_g^{min} is the lower boundary temperatures. Thus (14.2.10) becomes

$$\frac{T_g^{min}}{T_g^{max} - T_g^{min}} \leq 1. \quad (14.2.12)$$

From here

$$T_g^{max} \geq 2T_g^{min}. \quad (14.2.13)$$

14.3. Comparison with Carnot Cycle

Carnot cycle consists of 2 adiabatic and 2 isothermal processes. In (T, S) coordinates it is usually described as

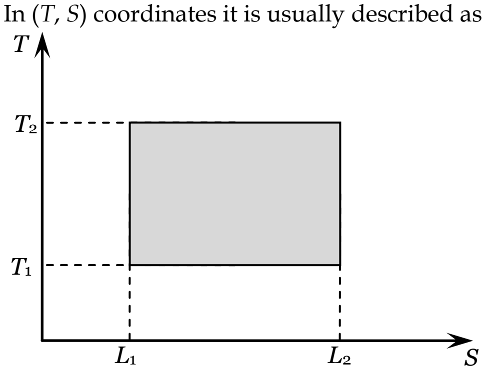


Fig. 14.3.1

It is believed that drawn rectangle square is efficient work in the cycle and $T_2(L_2 - L_1)$ rectangle square is the heat transmitted to the machine.

The Carnot thermic coefficient is usually defined as

$$\eta = \frac{(T_2 - T_1)(L_2 - L_1)}{T_2(L_2 - L_1)} = \frac{T_2 - T_1}{T_2} = 1 - \frac{T_1}{T_2}. \quad (14.3.1)$$

Let us consider it in greater details.

The rectangle in fig. 14.3.1 appears because adiabatic process is considered isentropic and temperature is isentropic process is believed to be constant today. Field analyses show that these suppositions are wrong.

1. Thermodynamic wave Eq. (14.1.1) yields that when we fix certain heat ω_0 in adiabatic process (adiabatic condition) we cannot fix entropy S_0: in that case immediately temperature T_0 must be fixed in accordance with Eq. (14.2.1) and the process stops. Therefore when we increase T_1 up to temperature T_2 along adiabatic curve 1 we must inevitably decrease entropy S_1 up to S_2. Symmetrically adiabatic process 2 takes place: when temperature T_2 is decreased to T_1 we inevitably must increase entropy S_3 up to S_4.

2. The picture in isothermal process is similar. Only boundary temperature T_g stays stable in them. The phase temperature inversely depends on entropy (Eq. (14.1.6)). In order to keep temperature stable we need additional heat to compensate entropy increase. But in this case there should third coordinate appear in fig. 14.3.1 to show this additional heat. One finally obtains: field cycle in (T, S) coordinates looks as in fig. 14.3.2.

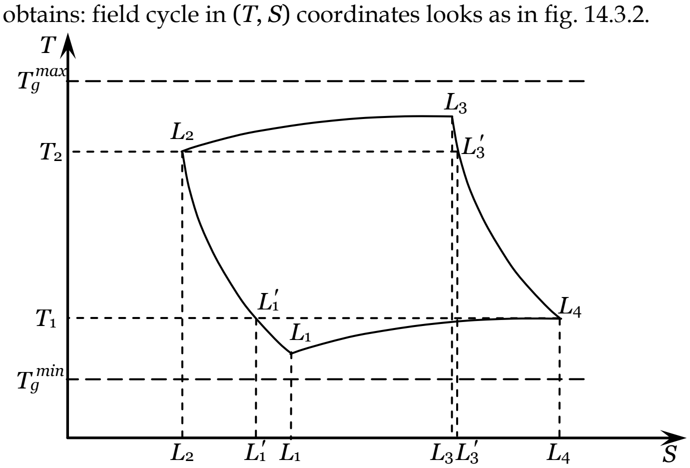


Fig. 14.3.2. Field Cycle.

Hyperbolic parts link L_1 and L_2, L_3 and L_4, instead of straight lines in fig. 14.3.2. If thermostat is not used phase temperature will not be stable and real process will go from L_2 not to L'_3 (dashed line) but to L_3 closer to T_g. Symmetrically the second isothermal process will go to S_1 and not to L'_1 (farther from T_g). Just these differences between fig. 14.3.2 and fig. 14.3.1 are determined by (14.2.7) and (14.2.9).

14.4. Conclusion about Such Cycles

We have shown above that second isothermal process in direct cycle induces the greater losses for us.

1. Perhaps we could use nonclosed cycle? In Carnot terms perhaps we could work without cooler? In field terms the problem would be to extract energy just from the field for instance from ocean. Nowadays when we understand accurate physical sense of heat and entropy such problem does not seem fantastic. But previously serious experimental program should be fulfilled.

2. It was recommended above to work at boundary temperature T_g. In this case the whole supplied energy transmits into entropy and vice-versa. The problem is that the very medium changes under such temperature. Therefore media in which heat completely transforms into temperature with fixed entropy seem very interesting for investigation. Such medium is theoretically well known: it is ideal gas. Ether possesses this quality. We mentioned in section 2 that having overcoming the ether boundary temperature T_0 we could extract energy just from ether. But scalar theory of thermodynamic field proposed in this chapter is not enough for this. Tensor field theory is necessary for this. But these authors hope that such theory will appear in some time. Certainly big experimental program is necessary on this way.

15. Hydrodynamic Model for Electron Motion

15.1. Main Equation

Newton's second law was developed long before the science of electricity, and so may be considered valid for a neutral body. It makes force **F** equal to a mass m multiplied it's acceleration **a**:

$$\mathbf{F} = m\mathbf{a}. \tag{15.1.1}$$

If one does not understand what force is, then this equation may be understood as the definition for force. On the other hand, in present-day physics there are many of different concepts of force: *i.e.,* force as potential gradient, electrodynamics force, *etc*. Therefore, it is often convenient to believe that we know what force means, that the concept is given to us by Nature as a realization of a certain external action on the subject under consideration. If so, then (15.1.1) may be considered as a reaction of an electrically neutral mass m to an external action **F**: the mass gains acceleration **a**.

In modern physics, Eq. (15.1.1) is generalized to

$$\mathbf{F} = \frac{d}{dt}(m\mathbf{v}) = m\mathbf{a} + \frac{dm}{dt}\mathbf{v}, \tag{15.1.2}$$

where **v** is particle velocity. The derivative dm/dt possess different physical meanings in different problems. In accord with the author gravity concept dm/dt in electrodynamics problems means the electron charge. So in electrodynamics, Eq. (15.1.2) appears as

$$\mathbf{F} = m\mathbf{a} + q\mathbf{v}, \tag{15.1.3}$$

where q is the electron's charge and **v** is its velocity. The first term in (15.1.3) describes the neutral-mass reaction and the second term describes the charged-body reaction, its electric pliability. This term is defined by the viscosity of the medium in which the movement takes place.

Let us call this medium "ether". The term "ether" is "red flag" for many physicists, but whatever other terms may be used for it, like "physical vacuum", *etc.*, even the most orthodox physicists are compelled to agree that space is in fact filled with a certain medium. And I hope all my readers are agreed that this medium possesses electrical resistance. We know precisely what this resistance is: vacuum impedance $1/\varepsilon_0 c$, where ε_0 is dielectric constant and c is the speed of light.

External action cannot be exhausted by the two terms in (15.1.3). As occurs in all typical media, inertial forces of the ether should also be displayed. The idea that ether should resist movement of charged bodies (and light) has been asserted by many authors, among whom perhaps the most consistent (known to the author) are Russian scientists P.D. Prussov, and G.A. Shlenov.

But here we strive not for qualitative assertions, but rather for quantitative and testable statements. We try to find the quantitative formula describing the resistance. Let us suppose that medium inertial forces are proportional to ether impedance $1/\varepsilon_0 c$, and that the constant ε_0 means ether density. If one takes into account the dimensions of parameters, the inertial forces should also be proportional to speed squared, v^2. To be in accord with the experimental results, let us take the coefficient of proportionality equal to ½. One finally gets:

$$\mathbf{F} = m\mathbf{a} + q\mathbf{v} - \frac{qv^2}{2c}\mathbf{e}, \tag{15.1.4}$$

where **e** is a unit vector in the direction of velocity **v**.

In order to avoid useless complexity, the assertions following will be formulated in scalar form for a projection of the vector Eq. (15.1.4). Equations for other projections can be derived in an analogous way. One has:

$$\frac{dv}{dt} = \frac{F}{m} - \frac{qv}{m} + \frac{qv^2}{2mc}. \tag{15.1.5}$$

Eq. (15.1.5) is first order with respect to v. Let us introduce the definitions

$$\frac{F}{q} = a, -1 = b, \ \frac{1}{2c} = p.$$

Then Eq. (15.1.5) reduces to the form

$$\frac{dv}{dt} = \frac{q}{m}\left[a + bv + pv^2\right]. \tag{15.1.6}$$

It is well known that Eq. (15.1.6) has a solution [41]. If $a + bv_0 + pv_0^2 \neq 0$, then the curve passing through point (t_0, v_0) is found as a solution with respect to v of the equation

$$\int_{v_0}^{v} \frac{dv}{\left(a+bv+pv^2\right)} = \frac{q}{m}\int_{t_0}^{t} dt. \tag{15.1.7}$$

If

$$a+bv_0+pv_0^2=0, \tag{15.1.8}$$

then the straight line

$$v=v_0 \tag{15.1.9}$$

is a solution.

Let us begin our analyses with solution (15.1.9). The solution of (15.1.8) is

$$v_0=\frac{-b\pm\sqrt{b^2-4ap}}{2p},$$

or taking into account our definitions

$$v_0=c\left(1\pm\sqrt{1-2F/qc}\right). \tag{15.1.10}$$

This equation has real solutions if

$$1-2F/qc\geq 0, \tag{15.1.11}$$

i.e., if force F is small enough. Force F which satisfies (15.1.10) has evident physical meaning: it preserves v_0. If this force acts on electron already moving with velocity v_0, that electron will continue moving with this velocity. This means that electron movement does not imply Newton's first law. Its movement is closer to that one of a car on the surface, or an airplane in the air.

If external force $F = 0$, then velocity

$$V=\frac{cv_0}{\left[v_0-\exp\left\{q/\mathrm{Im}\left(t-t_0\right)\right\}\left(c-v_0\right)\right]}, \tag{15.1.12}$$

i.e., velocity v exponentially decreases from achieved velocity v_0 when there is no external force.

15.2. Case 1: Subluminal Movement Motion

Let us come back to (15.1.6) equation and its solution (15.1.7). If inequality (15.1.11) holds strictly then solution is

$$V=\frac{\left[c\exp\left\{\frac{q\tau}{m}\left(t-t_0\right)\right\}\left(v_0-c(1+\tau)\right)(\tau-1)\right]}{\left[v_0-c(1-\tau)-\exp\left\{\frac{q\tau}{m}\left(t-t_0\right)\right\}\left(v_0-c(1+\tau)\right)\right]}+ \\ +\frac{c\left(\tau+1\right)\left(v_0-c(1-\tau)\right)}{\left[v_0-c(1-\tau)-\exp\left\{\frac{q\tau}{m}\left(t-t_0\right)\right\}\left(v_0-c(1+\tau)\right)\right]}, \tag{15.2.1}$$

where $\tau=\sqrt{1-U/c}$; $U = 2F/q$.

If $v_0 = 0$, $t_0 = 0$ then (15.2.1) becomes a little simpler

$$v=\frac{2F\left[\exp\left\{\frac{q\tau}{m}t\right\}-1\right]}{q\left[\left(-1+\tau\right)+\exp\left\{\frac{q\tau}{m}t\right\}\left(1+\tau\right)\right]}. \tag{15.2.2}$$

Force magnitude F is arbitrary here; it depends on our choice, but we consider it constant during integration process. When F is acquired, a speed U is also acquired. Eq. (15.2.2) implies that the velocity v gained by charge q is proportional to the velocity U defined by the force F acting on q. When $t = 0$, the fraction made of square brackets in the numerator and denominator reduces to

$$\frac{e^0-1}{2\tau},$$

i.e., it is null. When t grows, this fraction grows as well, and comes to unity, after which the electron preserves steady velocity U defined by the applied force F. The time interval from the start of motion up to achieving this velocity U is the time of the electron's accelerated movement.

It was assumed earlier that

$$1-U/c>0 \tag{15.2.3}$$

or equivalently, that

$$U=\frac{2F}{q}<c. \tag{15.2.4}$$

But one can see that correlation (15.2.2) is also reasonable when inequality (15.2.3) becomes an equality; *i.e.,* when

$$U=c. \tag{15.2.5}$$

Light velocity is apparently achieved in this case:

$$v=c. \tag{15.2.6}$$

This fact is coordinated to (15.1.10). It is necessary to emphasize that in order to achieve a certain velocity, just force, is essential and not forces impulse. Multiplier depending on t in (15.2.2) grows quickly with growing t, and converges to a certain constant depending on U. Therefore long action with constant force rather quickly leads the (15.2.2) solution to expression (15.1.10). The velocity becomes constant. Therefore big impulse enlarges the track covered, but does not guarantee velocity enlargement. This is also true with respect to energy spent for electron's acceleration: its gradient is essential, but not produced work.

Let us investigate some examples that explain the result we found. The electron's charge $q = 7.3\times10^{-10}$ kg/s, which implies $q/m = \omega = 8.1\times10^{20}$ Hz, *i.e.,* q/m is the angular velocity of the mass creating the electron.

Example 1.

Let $1 - 2F/qc = 1/4$, *i.e.,* $F = 3/8qc = 0.082$ Newton per electron. Then

$$v=\frac{4\cdot 0.041\cdot 10^{10}\left[e^{\omega t}-1\right]}{7.3\left[3e^{\omega t}-1\right]}\approx 1.5\cdot 10^8 \text{ m/s}.$$

Example 2.

Let $1 - 2F/qc = 0.0137$, *i.e.,* $F = 0.108$ Newton per electron. Then

$$v\approx 2.06\cdot 10^8 \text{ m/s}.$$

Example 3.

Let $1 - 2F/qc = 10^{-6}$, *i.e.,* $v = 0.10948$ Newton per electron. Then

$$v = 2.99 \cdot 10^{8} \text{ m/s}.$$

When $F = 0.1095$ Newton per electron, it achieves light velocity.

The force root τ in the proposed theory is in a certain sense analogous to relativistic root τ. But it differs in at least one essential aspect: its equality to zero does not lead to physically absurd infinities. A design change in the force root just changes the character of the motion, as we see below.

15.3. Case 2: Superluminal Movement Motion

In this case Eq. (15.1.10) does not possess real solutions, *i.e.,* there does not exist a conserving force for any initial velocity v_0. Nevertheless, Eq. (15.1.7) has a solution. Its left hand part is

$$\int_{v_0}^{v} \frac{dv}{a + bv + pv^2} = \frac{2}{\sqrt{4ap - b^2}} \arctan \frac{2pv + b}{\sqrt{4ap - b^2}} \Bigg|_{v_0}^{v}. \quad (15.3.1)$$

One gets after corresponding transformations

$$\frac{c\sqrt{U/c-1}(v - v_0)}{c^2(U/c-1) + (v-c)\cdot(v_0 - c)} = \tan\left(\frac{q\sqrt{U/c-1}}{2m}(t - t_0)\right). \quad (15.3.2)$$

Hence

$$v = \frac{[Uc - cv_0]\tan\left(\frac{q\sqrt{U/c-1}}{2m}(t-t_0)\right) + cv_0\sqrt{U/c-1}}{\left[c\sqrt{U/c-1} - (v_0 - c)\tan\left(\frac{q\sqrt{U/c-1}}{2m}(t-t_0)\right)\right]}. \quad (15.3.3)$$

If $v_0 = 0$, $t_0 = 0$, then

$$v = \frac{2F\tan\left(\frac{q\sqrt{U/c-1}}{2m}t\right)}{q\left[\sqrt{U/c-1} + \tan\left(\frac{q\sqrt{U/c-1}}{2m}t\right)\right]}. \quad (15.3.4)$$

Superluminal speed v oscillates about a mean speed U.

If $v_0 = c$, $t_0 = 0$, then

$$v = c + c\sqrt{U/c-1}\tan\left(\frac{q\sqrt{U/c-1}}{2m}t\right). \quad (15.3.5)$$

If force root is equal to zero, *i.e.,* $U = c$ then (15.3.5) implies $v = c$. This means that formulas for sublight and superlight velocities are coordinated when light barrier is overcome.

Mathematically, the tangent function has a break of the second type. Physically, the break points correspond to moments of radiation. This means that "near luminal" movement looks as follows: the electron rushes by the light barrier, irradiates, and falls down to subluminal speed. Its mean speed in such a process is close to light speed from below, or even from above, as takes place in the Cherenkov Effect.

Thus originates the idea of impossibility to overcome light barrier. One can propose a hydrodynamic interpretation for the fact. Light speed is a critical speed for ether flow around the electron. When this speed is achieved, laminar flow changes to turbulent flow. The vortices created are sensed by us as radiation. Let us use this concept to find some ether characteristics. Let us take as characteristic dimension electron its radius as $r_0 = 3.8\times10^{-13}$ m. The Reynold's number is

$$Re = \frac{cr_0}{\nu}, \quad (15.3.6)$$

where ν is kinematics' velocity of the ether for electron. Turbulent flow begins when $Re = 2000$. Thus

$$\nu = 5.7 \cdot 10^{-8} \text{ m}^2/\text{s}. \quad (15.3.7)$$

If ether mass density 1.74×10^{8} kg/m^3, then viscosity

$$\eta = \nu\varepsilon_0 = 10.66 \text{ kg/m}\cdot\text{s}. \quad (15.3.8)$$

Let us stress that everything said above refers to electric charge. Ether flows by electrically neutral bodies as an ideal liquid (or close to it). Apparently Euler's paradox is valid for electrically neutral bodies: ether does not resist its steady movement. Hence Newton's first law turns to be valid (or almost valid). Well known experiments showing mass dependence on speed "perhaps will force us to refuse of this" assumption. But this is an object of special consideration.

Let us return to formula (15.1.12). It implies that if v_0 achieves $2c$ in laminar region electrons begin moving without resistance. The problem is that turbulent flow begins when speed achieves $c = \sqrt{1/\varepsilon\mu}$. The problem can be solved if light velocity in the medium is low and current is created in another medium with higher light velocity. In this case electrons of usual current in the last medium can achieve $2c$ velocity in the first one. Apparently just this effect is observed in very well known cases of superconductivity. Temperature decreasing decreases light velocity in circuit and already speed of electrons in usual current achieves $2c$ velocity in circuit.

15.4. Summary of the Argument

A model is proposed in which an electron moves in a medium, ether, which is assumed to fill all space. The ether is not given any qualities *a priori*; we find out the qualities by the action of the ether on a moving object. Ether does not act on a massive body moving steadily in it (Newton's first law). This means for us that this medium acts on a mass as an ideal liquid (Euler paradox). Only accelerated movement needs force.

But an electron experiences a certain drag already even when moving steadily. This is because electron is a rotation of a certain mass. Mathematically this means that electron is a derivative of this mass with respect to time. Or stated in another way: a steadily moving electron is an accelerated mass. And ether resists such acceleration. Conditions when ether does not resist electron movement are found.

The received differential equation has solution which describes not only sublight but also superlight movement.

16. Elementary Particles

16.1. An Experimental Approach to Proton Structure

Let us take the Compton wavelength for the proton as the radius of the greater circumference creating the torus:

$$r_p = 2.1031\times10^{-16} \text{ m.} \tag{16.1.1}$$

One can see that r_p is accurately 1836 times less than the electron radius. Electric charges of the proton and electron are modulo equal. This means that the equatorial angular velocity of the proton is:

$$\omega_p = \omega_e/1836 = 4.435\times10^{17}\ \frac{\text{rad}}{\text{s}}. \tag{16.1.2}$$

Thus the equatorial velocity of a particle drawing the proton surface is:

$$\upsilon_p = r_p\omega_p = 93.2721\ \frac{\text{m}}{\text{s}}. \tag{16.1.3}$$

The electron's energy in rest consists of two equal parts: kinetic energies of meridional and equatorial curls:

$$\begin{aligned}&\tfrac{1}{2}m_e\left[(\omega_e r_e)^2 + (\Omega_e\rho_e)^2\right] = \tfrac{1}{2}m_e(c^2+c^2) = \\ &= m_e c^2 = 8.1871\times10^{-14}\ \text{kg}\cdot\text{m}^2/\text{s}^2.\end{aligned} \tag{16.1.4}$$

The energy of the proton's equatorial rotation is:

$$\tfrac{1}{2}m_p\upsilon_p^2 = 7.2756\times10^{-24}\ \frac{\text{kg}\cdot\text{m}^2\cdot\text{rad}^2}{\text{s}^2}. \tag{16.1.5}$$

Let us find the radius and angular velocity of the proton's meridional rotation. Experiment shows that energy of the proton at rest is:

$$m_p c^2 = 1.5033\times10^{-10}\ \frac{\text{kg}\cdot\text{m}^2\cdot\text{rad}^2}{\text{s}^2}. \tag{16.1.6}$$

The energy of equatorial rotation (16.1.5) is negligibly small in comparison with (16.1.6). Therefore we shall neglect it below, and assume that the whole energy of the proton is concentrated in its meridional rotation, *i.e.*:

$$\tfrac{1}{2}m_p\Omega_p^2\rho_p^2 = m_p c^2, \tag{16.1.7}$$

where Ω_p and ρ_p are unknown variables defining the angular velocity of proton's meridional rotation and radius of its lesser circumference.

The electron's spin was defined as impulse momentum of its meridional rotation:

$$m_e\left[\boldsymbol{\rho}_e\times(\boldsymbol{\Omega}_e\times\boldsymbol{\rho}_e)\right] = m_e\rho_e^2\boldsymbol{\Omega}_e = \tfrac{1}{2}\boldsymbol{\hbar}. \tag{16.1.8}$$

This means that spin is modulo a constant polar vector directed along lesser circumference tangent, *i.e.*, along angular velocity $\boldsymbol{\Omega}_e$. Experiment shows that proton's spin is also equal to ½**ħ**. This gives us second equation to find $\boldsymbol{\Omega}_p$ and ρ_p:

$$m_p\left[\boldsymbol{\rho}_p\times(\boldsymbol{\Omega}_p\times\boldsymbol{\rho}_p)\right] = m_p\rho_p^2\boldsymbol{\Omega}_p = \tfrac{1}{2}\boldsymbol{\hbar}. \tag{16.1.9}$$

(16.1.7) and (16.1.9) yield:

Lesser circumference radius:

$$\rho_p = 7.4355\times10^{-17} \text{ m.} \tag{16.1.10}$$

Thus ρ_p is not two times less as it is in electron but approximately three times less than r_p.

The lesser circumference angular velocity is:

$$\Omega_p = 5.7019\times10^{24}\ \frac{\text{rad}}{\text{s}}. \tag{16.1.11}$$

Thus lesser circumference rotation velocity $\rho_p\Omega_p$ is $\sqrt{2}$ times bigger light velocity in free ether c.

The lesser circumference linear velocity is:

$$u_p = \rho_p\Omega_p = \sqrt{2}c = 4.2397\times10^{8}\ \frac{\text{m}}{\text{s}}. \tag{16.1.12}$$

These divergences from electron are naturally manifested in magnetic moment value. Experimental value of proton magnetic moment in mechanic dimensionality:

$$M_p = 6.2263\times10^{-17}\ \frac{\text{kg}\cdot\text{m}^2\cdot\text{rad}^2}{\text{s}^2}. \tag{16.1.13}$$

Reproducing the same reasoning as in the previous section we use the correlation:

$$M_p = m_p\pi\rho_p^2\nu_p^2, \tag{16.1.14}$$

where m_p is proton mass and ν_p is angular velocity of vortexes on proton surface. We obtain using (16.1.13) and (16.1.14):

$$\nu_p = \pm1.464\times10^{21}\ \frac{\text{rad}}{\text{s}}. \tag{16.1.15}$$

Local light speed in the proton body is:

$$c_p = \rho_p\nu_p = 1.088\times10^{5}\ \frac{\text{m}}{\text{s}}. \tag{16.1.16}$$

We assume that local ether compressibility

$$\mu_p = 2.7928\mu_0, \tag{16.1.17}$$

and this is the reason why experimental data differs from theory.

We obtain ether mass density in the proton body from (16.1.16) and (16.1.17):

$$\varepsilon_p = \frac{1}{c_p^2\mu_p} = 1.5393\times10^{14}\ \frac{\text{kg}}{\text{m}^3}. \tag{16.1.18}$$

As in the case of electron, the gyromagnetic ratio defines the angular rotation velocity of the torus (16.1.2) in its equatorial plane.

Expressions (3.3.9) and (16.1.15) may be considered as magnetic charges of electron and proton. Actually just they appear in generalized Maxwell equations. Dirac's idea about such charges existence is denied nowadays because as the experiment shows a force similar to Coulomb one does not

appear between such charges if they exist at all. Such a force must not appear in our case between so defined charges (in contrast to Dirac's monopole). Interaction appears only between moving charges. The construction we have obtained explains why this effect takes place. In contrast to electric charge and spin magnetic charge does not act on the external ether: its force lines are inside the particle just as in the case of macroscopic toroidal solenoid. But in movement elementary vortexes from which torus surface consists begin perturbate external ether and this leads to appearance of a new interaction force between moving magnetic charges.

16.2. A 'non-Bhor' Approach to the Hydrogen Atom Construction

Meridional rotation in a positron does not create standing waves. Therefore, a positron atom is demolished much quicker than a hydrogen atom: the electron "falls" on the positron.

Electric charge is the initial condition for an electrodynamic field, and the proton and electron mass is one of necessary two initial conditions for gravidynamic field induced by electron and proton. If we knew border conditions for these fields we would obtain complete physical picture created by these fields in the vicinity of proton and electron. In this case generalized formulas for electrodynamic and gravidynamic interaction would describe their interaction.

But first we do not know these boundary conditions nowadays. And second there are many reasons to believe that the most important role in such interaction is played by the third field. Some manifestations of it are investigated today in the framework of thermodynamics and Schrödinger equations.

This field is called X-field here. We do not know its equations nowadays but we know its charge: it is spin. Apparently just it defines main features of the observed interaction picture between electron and proton. Electro- and gravidynamic fields add just some shades. The aim of this article is to propose rough description of the phenomena and leave some details for the future.

Local light velocity u_p (16.1.12) in the vicinity of the proton is greater than light velocity in free ether, and this is an essential distinction of proton from electron: proton changes ether density and compressibility in its vicinity. It is clear that with distance from the proton, this deformation should decrease and local light speeds should converge to light speed in free ether. Experiment shows that such convergence takes place discretely by steps, *i.e.*,

$$u_n = \omega_n r_n \underset{n\to\infty}{\to} c. \tag{16.2.1}$$

Here ω_n is angular velocity and r_n is radius of vortex proton originates in its vicinity on step n. The u_n may be interpreted as local light speed on step n.

Is this convergence monotonic? Experiment answers: no. There is at least one speed between u_p and c. This speed is

$$c_1 = c/137 = 2.19\times10^6 \text{ m/s}, \tag{16.2.2}$$

Today this velocity is interpreted as electron velocity on the lowest orbit in hydrogen atom. Another interpretation for it is proposed here as minimal local light velocity in the system of standing waves induced by proton in ether.

We come to a conclusion that there is a valley between two peaks u_p and c. The electron needs additional energy in order to ascend as to c as to u_p, *i.e.*, when it comes to proton and when it comes to free ether.

According Eq. (16.2.2)

$$c_1 = \omega_1 r_1, \tag{16.2.3}$$

where ω_1 is angular velocity and r_1 is the radius of the vortex generated by the parent torus in the area with the local velocity c_1.

Let us investigate way from c_1 to free ether. We adopt the following law of X-field charge conservation

$$m_e c_n r_n = \hbar \text{ for all } n = 1, 2, \ldots, 137. \tag{16.2.4}$$

Here c_n is local light velocity and r_n is the radius of the vortex induced by the proton on step n. Such vortexes actually coincide with concept of Faraday force lines. We shall often use this term below.

One obtains for n = 1,2...137

$$r_n = \frac{\hbar}{m_e c_1 n} = \frac{5.27}{10^{11} n} \text{ m}. \tag{16.2.5}$$

In particular

$$r_{137} = 3.85\times10^{-13} \text{ m}, \tag{16.2.6}$$

$$\omega_1 = c_1/r_1 = 4.2\times10^{16} \text{ rad/s}, \tag{16.2.7}$$

$$\omega_n = 4.2\times10^{16} n^2 \text{ rad/s}. \tag{16.2.8}$$

$$\omega_{137} = 137^2\omega_1 \approx 7.8\times10^{20} \text{ rad/s}, \tag{16.2.9}$$

r_{137} and ω_{137} are very close to radius and equatorial angular velocity of the electron. The number of curls on the path from the "hollow" with local light velocity c_1 to light velocity in free ether c coincides with fine constant. And this is certainly not a random fact. But physical cause of it apparently will be understood later.

We see that the first 137 force lines differ from the lines with greater numbers in that their radii are greater and their angular velocities are lesser than for the electron, *i.e.*, electron can be situated only inside these curls. Later it goes out into free ether. Or in other terms: the electron can be inside these 137 force lines; its jumps from one of them to another one corresponds to the discrete spectrum. The electron cannot penetrate other force lines; the continuous spectrum corresponds to its movement over these other lines.

Mathematically correlation (16.2.4) is similar to Bohr's quantum condition. But here it has understandable essence: it is conservation law for X-field charge. Just $\hbar$ and not $\hbar/2$ stands in the right hand part of (16.2.4). This means that force lines are bosons and not fermions. It becomes clear why frequencies of "rotation in Bohr's orbits" do not coincide with radiation frequencies. Radiation frequencies are defined by force lines frequencies, and are not connected with "electron movement", even when it really moves. Actually, the electron is in rest in the

undisturbed hydrogen atom. Therefore its orbital momentum is null.

Experiment shows that c_n increases as n. Taking (16.2.4) into account we can assert that r_n decreases as n and this means that ω_n increases as n^2.

The electron can sustain constant velocity indefinitely long only if it is in rest or moves with double local lights velocity (this means that it moves under condition of superconductivity). When the electron inside the c_1 vortex is struck with a photon or another electron, it comes to another vortex with a velocity that differs from double local light velocity. Therefore it begins moving with friction. Friction energy concentrates. The electron loses its energy and returns to its maternal vortex (force line).

Let us find formula for energy radiation in hydrogen atom when electron comes from force line n to force line m, $n > m$. Force line n possess the following kinetic energy

$$\tfrac{1}{2} m_e c_n^2 = \tfrac{1}{2} \hbar \omega_n. \tag{16.2.10}$$

This energy is necessary to destroy this force line. Experiments show that energy necessary to tear out electron from this line is n^2 times less. Therefore the energy formula for an electron coming from one force line to another one is

$$W_n - W_m = \frac{1}{2} \frac{\hbar(\omega_n - \omega_m)}{n^2 m^2}. \tag{16.2.11}$$

In particular

$$\begin{aligned} W_1 - W_{137} &= \tfrac{1}{2}\hbar(\omega_1 - \omega_{137})/137^2 = \\ &= 1.2\times10^{-22}\ \text{J} - 2.18\times10^{-18}\ \text{J} = \\ &= 7.5\times10^{-4}\ \text{eV} - 13.6\ \text{eV}. \end{aligned} \tag{16.2.12}$$

The minus sign means that energy is spent for the process.

Now let us come to the slope from proton to domain with local light velocity c_1. Accurate analysis here will be possible when neutron theory is constructed and some additional experimental facts that the author does not know nowadays are obtained. Therefore only just preliminary considerations are proposed below.

The following suppositions are assumed here.

1. Local light velocities decrease steadily and discretely from velocity $u_1 = u_p$ to velocity u_1.

2. The X-field charge conservation law is

$$m_p u_n r_n = \hbar, \tag{16.2.13}$$

where m_p is proton mass.

We assume that

$$u_1 = u_p = 4.2\times10^8\ \text{m/s}. \tag{16.2.14}$$

Hence

$$\frac{u_1}{c_1} = 192, \tag{16.2.15}$$

$$u_n = r_n \omega_n,\ n = 1,2,\ldots,192. \tag{16.2.16}$$

One obtains taking (16.1.17) into account

$$r_n = r_1 n,\ n = 1,2,\ldots,192, \tag{16.2.17}$$

$$\omega_n = \omega_1 / n^2,\ n = 1,2,\ldots,192.$$

r_1 and ω_1 may be found from (16.2.13), (16.2.11), (16.2.15)

$$r_1 = \hbar / m_p u_1 = 1.4\cdot10^{-16}\ \text{m}, \tag{16.2.18}$$

$$\omega_1 = u_1 / r_1 = 3\times10^{24}\ \text{rad/s}, \tag{16.2.19}$$

$$r_{192} = 2.7\times10^{-14}\ \text{m},$$

$$\omega_{192} == 0.814\times10^{20}\ \text{rad/s}, u_{192} = 2.2\times10^6 = c_1.$$

Thus although the 192-nd nuclear force line light speed is equal to the first atomic force line light speed, their radii and angular velocities are not equal. This means that there should be a domain between them with wavelengths from 2.7×10^{-14} m up to 5.27×10^{-11} m. X-rays in multi-electron atoms supply us with some information concerning this domain. When an electron moves to the nucleus, specific energy consumption sharply increase in the vicinity of these waves and the radiation spectrum becomes continuous. But when an electron overcomes this barrier, it reaches the nucleus comparatively easily. We can interpret this as a proof that the interval between u_{192} and c_1 is filled with negatively charged force lines. They create a Coulomb barrier for electron. But nuclear force lines are charged positively. And this helps the electron to reach the proton. These lines are too narrow for the electron. Therefore electron moves not sticking in them. This corresponds to a continuous radiation spectrum.

The proton moves symmetrically. It is braked on the external atomic lines c_n, accelerates in the interval between c_1 and u_{192} and again braked on nuclear force lines u_n. Proton size let it be inside all force lines. But u_n are charged positively. Therefore it can anchor only with the help of neutron. And this is a subject for special investigation.

Let us try to quantitatively evaluate energy picture when elementary particles cross force lines u_n. The electron moves similarly to the case of external c_n lines.

Let

$$\beta = 1/192. \tag{16.2.20}$$

The electron spends its energy when comes from u_{192} to u_n, $n < 192$. Electric field helps it but it must overcome X-field resistance. We assume the following formula

$$W_{192} - W_n = \tfrac{1}{2}\beta^2 \hbar(\omega_{192} - \omega_n). \tag{16.2.21}$$

In particular

$$\begin{aligned} \tfrac{1}{2}\beta^2\hbar(\omega_{192} - \omega_1) &= 1.16\times10^{-19}\ \text{J} - 4.27\times10^{-14}\ \text{J} = \\ &= 0.725\ \text{eV} - 2.67\times10^5\ \text{eV}. \end{aligned} \tag{16.2.22}$$

The minus sign means necessity to spend energy, just as for crossing external atomic lines c_n. The coefficient β^2 appears because electric field helps electron to overcome X-field. But electric field hinders proton movement. Therefore we assume the following formula for the proton:

$$W_{192} - W_n = \tfrac{1}{2}\hbar(\omega_{192} - \omega_n). \tag{16.2.23}$$

In particular, the proton needs energy

$$\tfrac{1}{2}\hbar(\omega_{192}-\omega_1)=4.28\times10^{-15}\text{ J}-1.57\times10^{-9}\text{ J}= \\ =2.67\text{ eV}-9.83\times10^{9}\text{ eV}. \quad (16.2.24)$$

to achieve other proton.

A more detailed picture should appear when the neutron construction is understood, because in complex nuclei the neutron prevents the electric field and X-field from scattering protons about.

In conclusion I would like to draw the attention of my reader to similarity in behavior of ether and hyper fluidal liquid, and invite for cooperation in all the problems mentioned here.

16.3. On Gravitational Belts in Atoms

The Proton torus lesser circle tangential velocity excess over light velocity in free ether results in the appearance of two series of vortexes in the surrounding ether. Just from the proton a series of 194 vortexes begins. Number 194 is the correction of the obtained earlier number 192 curls surrounding proton. This number was found in the previous paragraph. The angular velocities of these vortexes decrease as n^2, their radii increase as n. This means that their local light velocities decrease as n from u_p to $c/137$.

The radius of the first vortex is

$$r_1=\frac{h}{m_p u_p}=1.479\times10^{-16}\text{ m}. \quad (16.3.1)$$

Accordingly

$$r_{194}=194\cdot r_1=2.87\times10^{-14}\text{ m}. \quad (16.3.2)$$

The angular velocity of the first vortex is

$$\omega_1=u_p/r_1=2.87\times10^{24}\text{ rad/s}. \quad (16.3.3)$$

$$\omega_{194}=\omega_1/194^2=0.763\times10^{20}\text{ rad/s}. \quad (16.3.4)$$

The tangential velocity of the last 194-th vortex

$$u_{194}=r_{194}\omega_{194}=2.19\times10^{6}\text{ m/s}=c/137. \quad (16.3.5)$$

This is the last nuclear vortex.

The radius of the first vortex in atomic series is

$$\rho_1=5.27\times10^{-11}\text{ m}. \quad (16.3.6)$$

Its angular velocity is

$$\nu_1=\frac{c}{137\cdot\rho_1}=4.16\times10^{16}\text{ rad/s}. \quad (16.3.7)$$

Its local light velocity

$$c_1=\nu_1\rho_1=c/137=2.19\times10^{6}\text{ m/s}. \quad (16.3.8)$$

Radius ρ_n of atomic vortexes decrease as n

$$\rho_n=\rho_1/n,\ n=1,2,\ldots,137. \quad (16.3.9)$$

In particular

$$\rho_{137}=\rho_1/137=3.85\times10^{-13}\text{ m}. \quad (16.3.10)$$

Their angular velocities increase as n^2

$$\nu_n=\nu_1 n^2. \quad (16.3.11)$$

In particular

$$\nu_{137}=7.8\times10^{20}\text{ rad/s}. \quad (16.3.12)$$

The characteristic quality of 137 atomic vortexes is that their radii are bigger and their angular velocities are lesser than of the electron. Their mass is equal to electron mass. In other terms, the electron can be inside these and only these vortexes.

Local light velocities of the last nuclear vortex (16.3.5) and the first atomic vortex (16.3.8) are equal. But their radii and angular velocities essentially differ. Masses of vortices also differ. Nuclear vortices have the mass of the proton and atomic vortices have the mass of the electron. There exists a transition zone between these runs with angular vortexes from 0.762×10^{20} rad/s up to 4.16×10^{16} rad/s, *i.e.,* from wavelength 1.479×10^{-16} m up to 5.27×10^{-11} m.

Characteristics of nuclear and atomic vortices were obtained under condition that their impulse moment was equal to $\hbar$. This condition is preserved for the investigated zone as well. These vortices are named "gravitational" because their mass is variable.

The first problem is these vortices number. Their local light velocities are constant. This means that their radii must decrease in the same tempo as angular velocities increase.

$$R_n\varphi_n=c/137\approx2.19\times10^{6}\text{ m/s}. \quad (16.3.13)$$

Here R_n is radius and φ_n is angular velocity of the n-th vortex.

The number of vortices may be found from conditions (16.3.2) and (16.3.6) or (16.3.4) and (16.3.7).

$$n=\rho_1/r_{194}=\omega_{194}/\nu_1=1836. \quad (16.3.14)$$

The condition of constant impulse moment for gravitational vortexes appears as follows

$$m_n R_n^2\varphi_n=\hbar,\ n=1,2,\ \ldots,1836. \quad (16.3.15)$$

$$m_1=m_p,\ m_{1836}=m_e,\ R_1=r_{194},$$
$$R_{1836}=\rho_1,\ \varphi_1=\omega_{194},\ \varphi_{1836}=\nu_1.$$

The electron in the Hydrogen atom is apparently inside the first atomic vortex, with radius 5.27×10^{-11} m and angular velocity 4.16×10^{16} rad/s. Experiment shows that its orbital impulse is null, *i.e.,* it is at rest. This state is a stable equilibrium because the electron in it possesses minimal energy. It needs external energy in order to move, as inside to proton, or outside to free ether. It must overcome gravitational vortices with increasing mass in order to move to the proton, and atomic vortexes with increasing local light velocities in order to move outside.

Let us evaluate energy necessary for a massive particle for n-step penetration into gravitational belt. Lifting energy up to the n-th vortex is $\hbar\varphi_n$. Let the particle possess kinetic energy $\frac{1}{2}mv^2$. In general, the depth of penetration depends on the angle between the particle impulse and vortexes' light velocities. For a head-on collision, one has

$$\hbar\varphi_n = \frac{mv^2}{2}. \qquad (16.3.16)$$

Just this correlation we have for continuous X-ray radiation: the frequency is proportional to the energy of the radiating electron. In the case of charged particles, we must investigate the problem of atomic gravitational and nuclear vortexes charge. It was said that electric charge is defined by equatorial rotation of toroidal vortexes.

The problem with atomic vortexes seems to be clear. All 137 vortices are a unified system with unique positive charge. Just this system defines the charge of an ionized Hydrogen atom. When electron with opposite direction of its equatorial rotation appears in the system it neutralizes this rotation and makes the whole system electrically neutral.

Charge problem of nuclear vortexes system is less evident. But K-capture of electron by proton and some other experiments say in favor of this system positive charging. If this is so we are compelled to prescribe negative charge to gravitational belt.

Physically this means that electron need additional energy to penetrate this barrier and proton needs less energy. Nowadays it is difficult to evaluate this energy quantitatively.

It is not clear even with Coulomb formula. In addition we must take velocities and accelerations in consideration, *i.e.,* we must use generalized force formula (§2). We leave this problem for future investigation. Qualitatively one can assert that this additional force must be exhibited when charged particle overcome the belt. This means that absorption coefficient must jump on the belt boundary. Just this effect is observed in X-ray spectrum.

If atom nucleus includes several protons there should be several nuclear belts. Let us take Helium as an example.

Two oscillators with equal frequencies do not change frequency of the sum oscillation but double amplitude, *i.e.,* enlarge energy four times. There is something like this in our case. But here instead of making amplitude twice bigger the number of nuclear vortexes become twice less.

Sum frequency induced by two protons in ether is equal to frequency induced by one proton. But the first gravitational belt appears not in 194 but in 97 steps. Nuclear vortexes frequency decrease as n^2, *i.e.,*

$$\omega_{97} = 4\omega_{194}. \qquad (16.3.17)$$

Correspondingly minimal angular velocity of atomic vortexes increases in four times. One obtains for Helium

$$\psi_1 = 4\nu_1. \qquad (16.3.18)$$

Here ψ_1 is minimal angular velocity of the deepest atomic vortex and ν_1 is minimal (Bohr) angular velocity in Hydrogen atom, *i.e.,* Rydberg constant. Experiment shows that this number for Helium is a little more than for Hydrogen. It is believed that the cause of this result is bigger mass of Helium nucleus and corresponding increasing of gravitational attraction.

The proposed point of view explains it by superposition of neutrons' vibrations: their oscillations slightly differ from protons' ones. The same effect explains deviation of X-ray radiation from quadratic law with atoms' number increase. Actually it increases a little quicker. This effect is defined by nucleus construction which defines accurate location of gravitational belts. We shall return to this problem. And now formal calculations from previous section concerning electron in Hydrogen atom will be reproduced and compared with Helium. Energy increment when electron in Hydrogen atom comes from the first force line up to the last before take-off 137-th force line

$$\begin{aligned} W_1 - W_{137} &= \tfrac{1}{2}\hbar(\nu_1 - \nu_{137})/137^2 = \\ &= 7.5\times10^{-4}\ \text{eV} - 13.6\ \text{eV}. \end{aligned} \qquad (16.3.19)$$

Taking (16.2.2) into consideration, one obtains for Helium

$$\begin{aligned} W_1 - W_{137} &= \tfrac{4}{2}\hbar(\nu_1 - \nu_{137})/137^2 = \\ &= 3\times10^{-3}\ \text{eV} - 54.4\ \text{eV}. \end{aligned} \qquad (16.3.20)$$

One obtains for Lithium in the same way

$$\begin{aligned} W_1 - W_{137} &= \tfrac{9}{2}\hbar(\nu_1 - \nu_{137})/137^2 = \\ &= 6.75\times10^{-3}\ \text{eV} - 122.4\ \text{eV}. \end{aligned} \qquad (16.3.21)$$

We have obtained the spectroscopic law for Hydrogen-shaped atoms. The existence of additional neutrons in atoms leads to slight deviations from a quadratic law.

We have essentially the same situations with X-ray spectra, but with certain differences. Spectral lines are observed for X-rays only in emission spectra, and are never observed in absorbtion spectra. And what is more, in order that X-rays could be absorbed they always must completely ionize one of the shells K,L,M,.. at the expense of their $\hbar\nu$. In the framework of the proposed approach the most deep electrons in K,L,M,.. shells are inside vortexes which are based on gravitational belts. In order to reach these vortexes, the external photon or electron must spare some energy to overcome external vortexes. Only later can it pull out the internal electron from its vortex and move up to another vortex.

This is the picture in Hydrogen type atoms. The difference with X-ray is that raiding electron or photon must previously knock out the external electrons and only after them knock out the last electron near gravitational barrier. The rest of the photon energy penetrates the gravitational barrier showing continuous absorption spectrum.

But up to what atomic number can we construct Hydrogen type atoms? In strict accord with what is said above, we can do this up to number 97 atom. For these atoms there are not less than 2 force lines around atoms' nucleus from which gravitational belts can begin. But because of the influence of neutrons, this number is less or equal to 92, *i.e.,* to Uranium. Therefore, artificial atoms with greater numbers are not stable.

Let us investigate Helium atom in greater detail. It is well known that there exist two kinds of Helium: Parahelium with ionization energy of the second electron 24.5 eV and ordinary spectrum lines, and Ortohelium with triple lines beginning from metastable position.

In the framework of the proposed approach, these two kinds of Helium correspond to two different nuclear structures. The nucleus of the Helium atom consists of 2 protons and 2 neutrons. The neutron possesses stability because of hoops which adjacent proton produces. In other terms, in order to be stable the neutron must have as neighbor at least one proton, *i.e.,* one proton can

serve only one or two neutrons and not more. Therefore, Deuterium and Tritium, exist but Hydrogen isotope with three neutrons does not exist. Section 5 is devoted to more detailed investigation of this problem. Therefore we are not able to create neutron substance. Cores made of all protons do not exist because of electrical causes. A special paper devoted to quantitative analyses of the problem will be written later.

Here these problems are mentioned only to qualitatively explain peculiarities of α-particles and cores in general.

Thus theoretically accepted look include three types of α-particles. The first is puff-pastry when protons and neutrons alternate. The second and the third types are models with two internal protons and external neutrons and two internal neutrons and external protons. These differences do not influence the position of the first gravitational belt, but changes position of the second one and define differences in Ortho- and Para-helium. Experiment will give us the final answer. Here we curb ourselves with some preliminary considerations.

The triple spectrum of Ortho-helium apparently corresponds puff-pastry structure because it contains more contacts between neutrons and protons. Just these contacts define super-fine structure of spectra.

The spectrum of the other construction corresponds to Para-helium. The model with two internal protons seems to be more truth-like because Helium has no stable isotopes with three neutrons.

Let us shortly repeat everything said above. Cores' and correspondingly atoms' construction is defined by vortices that protons and neutrons create in the surrounding ether interacting with each other. The system of vortices starting in the vicinity of the nucleus is made of high frequency vortices with the mass of protons and neutrons. The system of external atomic vortexes consists of lower frequency vortexes with electron mass. Therefore nuclear interactions are highly energetic and atomic and molecular interactions are less energetic.

The transition from nuclear system to atomic one takes place not by jump but through a series of vortices with decreasing mass. In multi-electronic atoms, these gravitational belts define X-ray radiation, and their positions in the system of nuclear vortices define type of electronic shells in atoms. Nuclear construction defines the position of gravitational belts.

16.4. Neutron Construction

External Characteristic of the Neutron

We preserve here the concept of long-lived elementary particles as vortical toruses, and transfer that idea to the neutron. The neutron is not charged, *i.e.,* its surface does not exhibit equatorial rotation.

The electron's kinetic energy consists of two equal parts: energy of meridional rotation, and energy of equatorial rotation.

The kinetic energy of the proton's equatorial rotation is negligibly small because of the low angular velocity of equatorial rotation, and the small radius, although just this rotation determines proton's charge. Almost the whole kinetic energy of the proton is concentrated in its meridional rotation.

The neutron's kinetic energy is completely determined by meridional rotation too. It is known that:

$$m_n c^2 = 1.5075\times10^{-10}\ \mathrm{kg\cdot m^2/s^2}, \qquad (16.4.1)$$

where m_n is the neutron mass. For comparison, the proton energy is the same:

$$m_p c^2 = 1.5057\times10^{-10}\ \mathrm{kg\cdot m^2/s^2}. \qquad (16.4.2)$$

If Ω_n and ρ_n are the angular velocity and the small circumference radius of the neutron, then:

$$\tfrac{1}{2} m_n \Omega_n^2 \rho_n^2 = m_n c^2. \qquad (16.4.3)$$

Here Ω_n and ρ_n are unknown variables. The neutron spin supplies us with the second equation necessary to find Ω_n and ρ_n:

$$m_n \Omega_n \rho_n^2 = \tfrac{1}{2}\hbar. \qquad (16.4.4)$$

Eqs. (16.4.3) and (16.4.4) yield the neutron smaller circumference radius:

$$\rho_n = 7.4253\times10^{-17}\ \mathrm{m}. \qquad (16.4.5)$$

This is a little bigger than the proton small circumference radius (16.1.10). The angular velocity of neutron surface meridional rotation is:

$$\Omega_n = 5.7098\times10^{24}\ \mathrm{rad/s}. \qquad (16.4.6)$$

This is less than the proton meridional angular velocity (16.1.11).

Internal Structure of the Neutron

The following experimental facts supply us with a basis for proposing a model for the internal construction of the neutron.

1. The proton is able to seize the electron and become a neutron. Nevertheless, the neutron mass turns out to be bigger than the sum of the masses of the proton and electron.

2. The neutron is stable only inside a nucleus. It decomposes rather quickly when free.

3. The internal regions of the neutron are not electrically neutral. The neutron "core" is charged positively, and its outlying districts are charged negatively.

This all leads us to the following qualitative model. When the small but massive proton turns to be inside the big torus of the electron, it draws in its mass into a layer of radius

$$d = (7.4355 - 7.4253)\times10^{-17}\ \mathrm{m} = 0.0102\times10^{-17}\ \mathrm{m}. \qquad (16.4.7)$$

This is the diameter of the lesser circumference of the compressed electron. We accept as the radius of the bigger circumference of the compressed electron the radius of the neutron.

The neutron is electrically neutral. This is possible in two cases:

1. The proton and the electron stop their equatorial rotation, or

2. The electron and the proton preserve their equatorial rotation, but perform them in the opposite directions.

The above mentioned experimental fact number 3 excludes the first supposition and selects the second one. Let us note at the

same time that the compressed electron does not need to change its equatorial rotation angular velocity in order to preserve its charge value: that is determined only by the mass that passes the torus cross-section per second, and does not depend on the torus radius or its lesser or larger circumferences. This means that values of angular velocities of the electron and proton equatorial rotation are preserved.

But if the electron and proton equatorial angular velocities are directed oppositely, then their spins must be co-directed, *i.e.*, their smaller circumferences must rotate in the same direction and their sum spin must be equal to $\hbar$. This spin co-direction must lead to the appearance of a repulsive force, which would tear apart the association between the electron and the proton if not compensated by a certain "hoop" action.

Let us try to describe this hoop action. First of all: From where does it appear? Experiment shows that this hoop works only when a proton is near. Although we do not understand the mechanism for creation of such a hoop, experiment persuades us of its existence. We know this hoop mass: 1.5 times the electron mass.

The neutron spin is equal to $½\hbar$. We can interpret this as meaning the hoop rotates oppositely to the proton and electron smaller circumferences rotation. Theoretically two situations are possible:

1. Hoop spin is equal to $½\hbar$. It compensates one half of the sum spin of the electron and the proton. Just the other half of the electron and proton common spin is observed in experiment.

2. Hoop spin is equal to $3/2\hbar$. It suppresses the common spin of the electron and proton. We observe in the experiment the remaining half of the hoop spin.

But the neutrino has spin $½\hbar$ (and the neutrino is presumed to have been the hoop in the neutron). This means that our first supposition is valid. Now we can understand why neutrinos of different chirality appear when neutron and anti-neutron decompose, because hoop rotation in the anti-neutron must be directed oppositely to that in the neutron.

The hoop performs only meridional rotation; it does not perform equatorial rotation. We know this because neutrino is not charged. We can evaluate angular velocity of the hoop meridional rotation:

$$m_h \rho_n^2 \omega_h = 1/2\hbar. \tag{16.4.8}$$

Here m_h is the hoop mass, equal to difference between neutron and proton masses, and ρ_n is neutron lesser circumference radius (16.4.5), ω_h is the required angular velocity of the meridional rotation of the neutron external surface; *i.e.*, of the hoop:

$$\omega_h = \frac{\hbar}{2m_h \rho_n^2} = 4.148 \times 10^{27} \text{ rad/s}. \tag{16.4.9}$$

We can also find the angular velocity of the compressed electron meridional rotation. In order to preserve its spin, the compressed electron must essentially enlarge its lesser circumference angular velocity because its lesser diameter of it (16.4.7) has become much less:

$$m_e \rho_{com}^2 \omega_e = 1/2\hbar. \tag{16.4.10}$$

Here m_e is electron mass, ρ_{com} is the lesser circumference radius of the compressed electron, equal to $d/2$ in (16.4.7), ω_e is the required angular velocity. Substituting known values of m_e and ρ_{com} into (16.4.10) produces:

$$\omega_e = \frac{\hbar}{2m_e \rho_{com}^2} = 2.2254 \times 10^{34} \text{ rad/s}. \tag{16.4.11}$$

Magnetic Moment of the Neutron

We assumed in the previous paragraphs that the electron preserves its charge and spin when being distorted. We also assumed that the proton preserves its size, *i.e.*, it preserves its characteristics. We obtained hoop's parameters based on neutron experimental parameters. Can we assume now that distorted the electron magnetic moment is also preserved? I do not feel so. Therefore two models corresponding to two extreme suppositions are investigated below.

Assumption 1. The values of the proton and electron magnetic moments are preserved within the neutron structure.

We assumed the proton to not be distorted. This means that it preserves angular velocity of the elementary circumferences that constitute its surface and rotation, which determines its magnetic moment. But angular the velocity of the compressed electron's elementary circumferences in the neutron structure must essentially increase, because magnetic moment is proportional to the lesser torus circumference squared.

In accord with the definition:

$$m_e \pi \rho_{com}^2 \omega_M^2 = M_e, \tag{16.4.12}$$

Here ω_M is the required angular velocity of the rotation around elementary circumferences of the compressed electron.

Hence:

$$\omega_M^2 = \frac{M_e}{m_e \pi \rho_{com}^2} = 5.5056 \times 10^{54} \ \frac{\text{rad}^2}{\text{s}^2}, \tag{16.4.13}$$

i.e.,

$$\omega_M = 2.3464 \times 10^{27} \ \frac{\text{rad}}{\text{s}}. \tag{16.4.14}$$

In the neutron structure, the directions of electron and proton spins coincide; *i.e.*, their magnetic moments must sum. Hoop spin is directed oppositely, *i.e.*, its magnetic moment is also directed oppositely. Experiment shows that the neutron magnetic moment is negative. This means that the modulus of the hoop magnetic moment exceeds the sum of electron and proton moments. We can find the value of the hoop magnetic moment M_h:

$$M_h = M_n - M_e - M_p. \tag{16.4.15}$$

Here M_e, M_p, M_n are the magnetic moments of the electron, proton, and neutron, respectively.

Expressed in mechanical dimensions, the neutron magnetic moment is:

$$M_n = 4.259 \times 10^{-17} \ \frac{\text{kg} \cdot \text{m}^2 \cdot \text{rad}^2}{\text{s}^2}. \tag{16.4.16}$$

Taking (16.3.8) and (16.3.21) into account one obtains:

$$M_h = -4.1 \times 10^{-14} \ \frac{\text{kg} \cdot \text{m}^2 \cdot \text{rad}^2}{\text{s}^2}. \tag{16.4.17}$$

Assumption 2. Proton and electron in neutron preserve angular velocities of the particles drawing elementary circumferences composing their surfaces.

As in the previous case, we believe the proton is not deformed; *i.e.*, the proton preserves its magnetic moment as well. The electron magnetic moment must become essentially less:

$$M_e^d = m_e \pi \rho_{com}^2 \nu_e^2. \qquad (16.4.18)$$

Here M_e^d is magnetic moment of the compressed electron, ν_e is the angular velocity of the particles drawing elementary circumferences of the free electron (16.3.7). Substituting numerical values one obtains:

$$M_e^d = 2.8592 \times 10^{-27} \ \frac{\text{kg} \cdot \text{m}^2 \cdot \text{rad}^2}{\text{s}^2}. \qquad (16.4.19)$$

One obtains substituting M_e^d in M_e:

$$M_h = -1.9673 \times 10^{-17} \ \frac{\text{kg} \cdot \text{m}^2 \cdot \text{rad}^2}{\text{s}^2}. \qquad (16.4.20)$$

We have investigated two extreme cases. Certainly the compressed electron could change, as magnetic moment, as angular velocities change. So experiment must give us the final answer to the question. By this I mean experiment measuring the magnetic moment of the neutrino.

17. Second Law of Thermodynamics and the Element Helium

17.1. Ideal Gas Characteristics

Let us preliminary reminds the ideal gas description in modern thermodynamics. They start from the initial correlation defining entropy

$$\delta q = TdS. \qquad (17.1.1)$$

Here q is heat, T is temperature, S is entropy. Variation differentiating symbol δ is used to stress that calorie increment is nonlocal, *i.e.*, it depends on the whole function. It is said sometimes that δq is partial differential meaning that its integral depends on the whole prehistory. Physically this means that we must limit ourselves with only quasistatic processes of heat transfer. Thermodynamic investigations of non-equilibrium processes become a special and a very difficult problem.

The heat quantity absorbed by ideal gas is usually defined by the equality

$$\delta Q = dU + pdV. \qquad (17.1.2)$$

Here U is internal energy, p is pressure and V is volume. Let us note that pdV is non-local differential. The items in the right hand part of (17.1.2) for ideal gas are reduced to functions depending on temperature:

$$dU = c_V dT. \qquad (17.1.3)$$

Here c_V is constant interpreted as specific heat capacity with constant volume. It has dimension of entropy.

Using Clapeyron theorem one obtains:

$$pdV = c_V \ln Tdt. \qquad (17.1.4)$$

And finally

$$dQ = c_V dT + c_V \ln TdT. \qquad (17.1.5)$$

Here q depends only on T and correspondingly dQ is complete differential. After integrating one obtains formula describing dependence of q on T:

$$Q = c_V (T \ln T - T_1 \ln T_1), \ T \in [T_1, T_2], \ c_V = \text{const}. \qquad (17.1.6)$$

Let us consider the same problem in the framework of generalizes thermodynamics. In order to avoid the problem of partial differentials and necessity to consider only quasistatic processes the generalized thermodynamics start not from (17.1.1) but from the following equality

$$Q = TS, \qquad (17.1.7)$$

connecting heat Q, temperature T and entropy S. Differential

$$dQ = TdS + SdT \qquad (17.1.8)$$

is evidently complete. Correlations (17.1.7) and (17.1.8) are valid for any processes. If T is constant the process is isothermal and (17.1.8) coincides with (17.1.1) and becomes partial differential.

(17.1.4) means that entropy for ideal gas

$$S = S_0 (\ln T + 1), \qquad (17.1.9)$$

i.e., heat

$$Q = TS_0 \ln T, \ T \in [T_1, T_2], \ S_0 = \text{const}. \qquad (17.1.10)$$

Constant entropy S_0 coincides with c_V for ideal gas. Its physical sense can differ for other gases.

Differentiating (17.1.10) one obtains for ideal gas:

$$\frac{dQ}{dT} = S_0 \ln(T+1) > 0, \ S_0 > 0. \qquad (17.1.11)$$

The derivative in the left hand part here will be called specific heat capacity. In modern thermodynamics specific heat capacity is defined in terms of finite increments because of the initial correlation (17.1.1). (17.1.7) enables us to do this in terms of differential equations and use all the capabilities of the corresponding apparatus. This also clarifies the physical sense of the specific heat capacity: specific heat capacity is just the velocity of the heat changing with the temperature and this velocity is definition of entropy. Therefore terms specific heat capacity and entropy will be used as equivalent ones.

The right hand part of (17.1.11) shows entropy dependence on temperature for ideal gas. Other functions do this for other media.

Let us calculate the other derivatives:

$$\frac{d^2 Q}{dT^2} = \frac{S_0}{T} > 0, \qquad (17.1.12)$$

$$\frac{d^3 Q}{dT^3} = \frac{d^2 S}{dT^2} = -\frac{S_0}{T^2} < 0. \qquad (17.1.13)$$

(17.1.12) > 0, thus heat q is convex (down) function, its chord lies higher than its graph (fig. 17.1.1). This means that ideal gas heat decreases faster than its arithmetic mean.

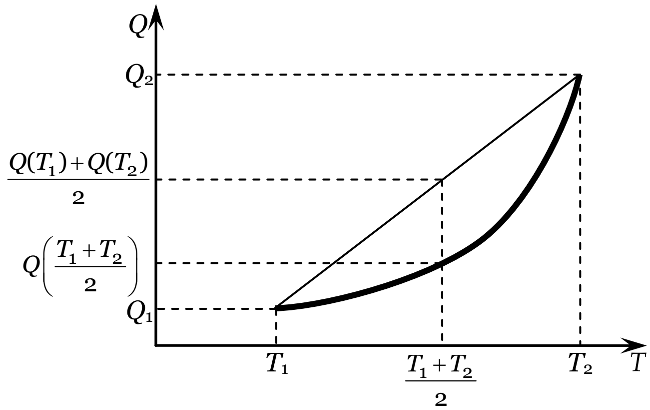


Fig. 17.1.1. Convex (down) function $Q(T)$.

(17.1.13) < 0, thus ideal gas entropy (17.1.11) is a convex (up) function, its chord lies lower than its graph (fig. 17.1.2). This means that ideal gas entropy increases faster than its arithmetic mean.

Let us consider problem of the movement direction of the heat q and entropy S with temperature. One obtains on gradient definition

$$\nabla Q = \frac{dQ}{dT}\nabla T, \tag{17.1.14}$$

$$\nabla S = \frac{d^2Q}{dT^2}\nabla T. \tag{17.1.15}$$

In the case of ideal gas coefficient before the gradients are positive, *i.e.,* (17.1.14) and (17.1.15) are positive. Generalized forces created by gradient are directed against it, *i.e.,* ideal gas heat and entropy decrease from "hot to cold".

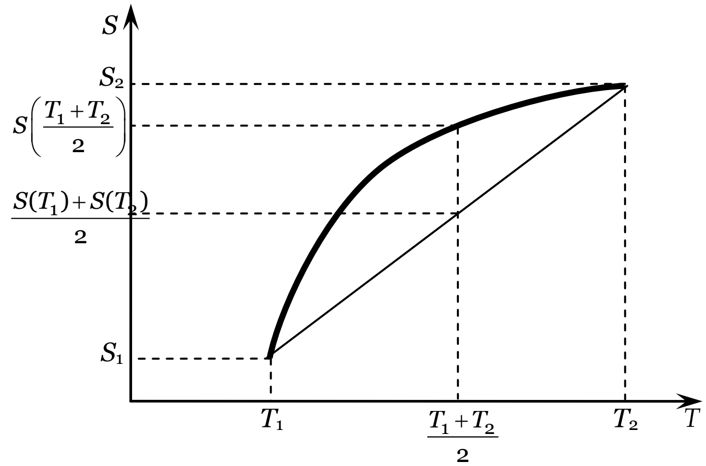


Fig. 17.1.2. Convex (up) function $S(T)$.

Sum total.

1. Ideal gas heat and entropy move from hot region to cold one.

2. Ideal gas heat is a convex (down) function. Its mean decreases faster than its arithmetic mean in any process with changing temperature.

3. Ideal gas entropy is a convex (up) function. Its mean increases faster than its arithmetical mean in any process with changing temperature.

One can say shortly but not accurately: "Ideal gas heat always decreases and ideal gas entropy always increases." These ideal gas characteristics have become a basis for the second principle in thermodynamics. They are assumed to be valid for any medium.

We plan to show that this is not so for liquid ^{2}He.

17.2. Liquid Helium Characteristic

These characteristics were found experimentally. (fig. 17.2.1) shows helium specific heat capacity (entropy) dependence on temperature.

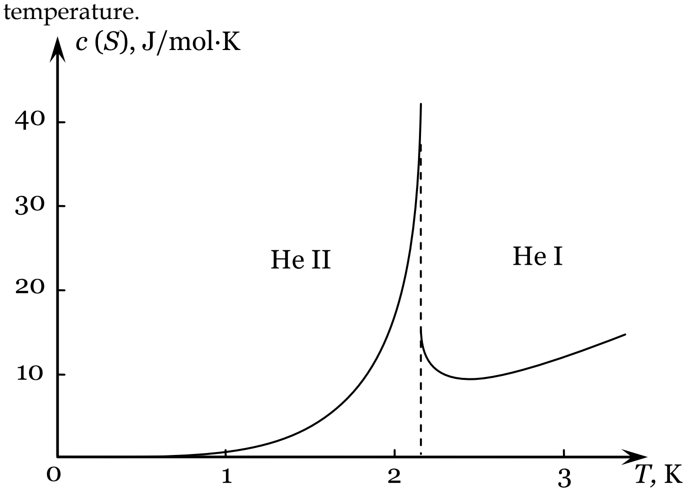


Fig. 17.2.1. Liquid helium lowest pressure lambda point.

1. On the interval [1.4, 2.18) the specific heat capacity grows approximately quadratically, *i.e.,* convex (down):

$$\frac{dQ}{dT} = \alpha T^2 > 0,\ T \in [1.4,\ 2.18),\ \alpha > 0,\ \alpha = \text{const}. \tag{17.2.1}$$

1.1. This means that entropy decreases faster than its arithmetic mean. This contradicts the second thermodynamics law and ideal gas characteristics in particular.

One obtains formula for heat integrating (17.2.1):

$$Q = \frac{a}{3}T^3 > 0,\ T \in [1.4,\ 2.18). \tag{17.2.2}$$

1.2. (17.2.2) is convex (up). This coincides qualitatively but not quantitatively with ideal gas characteristics. The second law of thermodynamic does not consider this characteristic.

$$\frac{d^2Q}{dT^2} = 2\alpha T > 0. \tag{17.2.3}$$

1.3. (17.2.1) is positive, *i.e.,* heat moves from hot to cold. This characteristic qualitatively coincides with the second law. (17.2.3) is positive. The second low does not mention this aspect.

2. On the interval [2.18, 2.7) the specific heat capacity decreases approximately temperature inverse and convex down:

$$\frac{dQ}{dT} = \frac{\beta}{T} > 0,\ T \in [2.18,\ 2.7),\ \beta > 0,\ \beta = \text{const}. \tag{17.2.4}$$

2.1. Entropy decreases in condition to the second law. Specific heat capacity is positive, *i.e.,* heat moves from hot to cold in concordance to the second law.

2.2. One obtains heat integrating (2.4):

$$Q = \beta \ln(T/T_1),\ T_1 = 2.18,\ T \in [2.18,\ 2.7). \tag{17.2.5}$$

The function is convex (up). The heat increases faster than its mean. There is no corresponding assertion in the second law.

2.3. $$\frac{d^2Q}{dT^2} = -\frac{\beta}{T^2} < 0. \tag{17.2.6}$$

(17.2.6) < 0, entropy moves from cold to hot. The second law does not mention this problem.

3. When $T \in [2.7, 4.2)$ the specific heat capacity stays convex (down) but begins increasing and less convex. It can be approximately describes by the function

$$\frac{dQ}{dT} = \frac{\gamma}{\sqrt{T}} > 0,\ \gamma > 0. \tag{17.2.7}$$

It is convex (down).

One obtains integrating

$$Q = 2\gamma\sqrt{T}, \tag{17.2.8}$$

$$\frac{d^2Q}{dT^2} = -\frac{\gamma}{2\sqrt[3]{T^2}}. \tag{17.2.9}$$

Helium characteristics on this interval are qualitatively similar to its properties on the previous interval.

17.3. Conclusion on Helium

The second law of thermodynamics postulates entropy increase in non-equilibrium processes. In particular it is assumed that if we unite two volumes of gas or liquid with different temperatures and entropies then in some time we obtain a system with mean temperature, but entropy of such a system will be higher than arithmetic mean of the united parts. As we saw higher this assumption is the consequence of the convexity (up) of the ideal gas entropy as temperature function. Apparently all media experiments with which were put into the second law foundation obtain this property. ^{2}He entropy as we saw is convex (down) on the all intervals and consequently decreases when the above described unification is realized.

It is assumed as evident in the second law that heat changes in the same direction that temperature does, *i.e.*, heat moves from "hot to cold". ^{2}He characteristics is in concordance with this assumption.

The problem of entropy direction even is not put in thermodynamics. ^{2}He entropy moves from cold to hot and vice-verse on different temperature intervals.

18. The Structure of Light Waves

18.1. Preliminary Information

The light will be understood as a wave in ether. Therefore some information from §13–15 will be reproduced here. One of the consequences of such understanding is that ether is an ideal gas. We shall call this ether as ether-1 in order to distinguish it from ether-2 whose particles rotate and create the particles of ether-1.

In addition to traditional three-dimensional system of Cartesian coordinates, whose points are designated as $\mathbf{x} = (x_1, x_2, x_3)$ the system of coordinate planes was introduced. Its points will be designated as $\boldsymbol{\varphi} = (\varphi_1, \varphi_2, \varphi_3)$. Physically $\mathbf{x}$ characterizes distance, length, and $\boldsymbol{\varphi}$ characterizes square or angle. Thus all functions turn to depend on as length as angle. Angle becomes an independents argument characterizing physical processes just as length does it.

Any angle can be expressed with the help of two points on the plane where it is defined. Linear character of light movement let consider movement along coordinate axis x_1 only.

It was shown in §13 that $\sin\varphi_1$ perpendicular axis x_1

$$\sin 2\varphi_1 = \frac{x_2 x_3}{x_2^2 + x_3^2} = 2z_1,$$

i.e.,

$$\arcsin 2z_1 = 2\varphi_1 = \int \frac{2dz_1}{\sqrt{1-4z_1^2}}. \tag{18.1.1}$$

From here

$$\varphi_1 = \frac{\int x_3 dx_2 - \int x_2 dx_3}{x_2^2 + x_3^2}\ \text{rad}. \tag{18.1.2}$$

Its time derivative

$$\frac{d\varphi_1}{dt} = \frac{\dot{x}_3 x_2 - \dot{x}_2 x_3}{x_2^2 + x_3^2}. \tag{18.1.3}$$

φ_1 is torsion wave angle and (18.1.3) is angular velocity of screw line. The fraction denominator defines the wave amplitude and derivatives describe velocity of coordinates changes perpendicular x_1.

In §3 and §6 it was shown that electron is a torus the grater rotation radius of which $r_e = 3.85\times10^{-13}$ m. Ether particle drawing this torus performs two rotations: 1) along the bigger circumference of radius r_e with the angular velocity $\omega_e = 7.8\times10^{20}$ rad/s. This rotation determines electrons electric charge $m_e\omega_e = 7.1\times10^{-10}$ kg/s, where m_e mass of electron. 2) Electron's spins is determined by rotation along the less circumference. Its radius is twice less r_e but angular velocity is twice bigger ω_e. Therefore electron's spin

$$\frac{\hbar}{2} = \frac{1}{2} m_e r_e^2 \omega_e. \tag{18.1.4}$$

18.2. Light Wave Kinematics

Assumption 1. Ether-1 particles whose oscillation transmits light wave is actually electrons without electric charge, *i.e.*, without ring rotation and "magnetic winding". We call this medium ether-1.

Assumption 2. Sigh wave kinematics is defined by time derivative

$$\frac{d}{dt}(x_1\cdot\varphi_1)=\frac{dx_1}{dt}\varphi_1+x_1\frac{d\varphi_1}{dt}. \tag{18.2.1}$$

Derivative dx_1/dt is just light speed c. Angular velocity $d\varphi/dt$ – is oscillation frequency of the particles which originated the light wave. We designate it as ω and the corresponding wave length as μ. Finally one obtains

$$\frac{d}{dt}(x_1\cdot\varphi_1)=c\varphi_1+x_1\omega. \tag{18.2.2}$$

Experiments show that light wave moves along x_1 with velocity c, *i.e.*, $x_1 = ct$. Thus

$$\frac{d}{dt}(x_1\cdot\varphi_1)=c\varphi_1+ct\omega. \tag{18.2.3}$$

The first item here describes rotation angle of the linear wave movement and the second one determines the speed of such rotation.

Assumption 3. The wave amplitude pulsates in the accordance with the law

$$x_2^2+x_3^2=r_e^2+\mu^2\sin^2\omega t. \tag{18.2.4}$$

Now we need to describe wave torsion. Let introduce the notion of screw wave length. It is connected with the longitudinal wave length.

$$\nu=\mu/2\pi. \tag{18.2.5}$$

Assumption 4. The velocity of changing of coordinates x_2 and x_3 determining torsion

$$x_2'=x_3'=\nu\omega=c. \tag{18.2.6}$$

Assumption 5.

$$r_e^2=2x_2x_3. \tag{18.2.7}$$

This supposition links thermodynamic wave square with x_2 and x_3 oscillations: this square one half of the thermodynamic wave square.

One obtains from (18.2.7) and (18.2.4)

$$x_3-x_2=\pm\mu\sin\omega t. \tag{18.2.8}$$

Selecting the sign in (18.2.8) one selects polarization. We take "+".

After integrating the first item in (18.1.2) from r_e to x_2 and x_3 one obtains:

$$\frac{d}{dt}(x_1\cdot\varphi_1)=c\frac{\int_{r_e}^{x_3}x_2dx_3-\int_{r_e}^{x_2}x_3dx_2}{x_2^2+x_3^2}+c\frac{\dot{x}_3x_2-\dot{x}_2x_3}{x_2^2+x_3^2}= \\ =\frac{c\mu\sin\omega t}{r_e^2+\mu^2\sin^2\omega t}\left[r_e+ct\right]. \tag{18.2.9}$$

Coefficient before square brackets determines amplitude variability. Its dimension is rad/s. The first item in square brackets is minimal distance of the screw line from x_1 axis. The second item is the path covered by the wave.

$m_e r_e \omega_e$ describes rotation impulse of ether-1 particle. When equality (18.2.9) is multiplied by this impulse one obtains expression of the thermodynamic wave impulse:

$$m_e r_e\omega_e\frac{d}{dt}(x_1\cdot\varphi_1)=\frac{c\mu\sin\omega t}{r_e^2+\mu^2\sin^2\omega t}\left[\hbar+m_ec^2t\right]. \tag{18.2.10}$$

Let us consider the process of obtain the second item in square brackets. c^2 contains two light velocities of different nature. The first one is linear speed c from the square brackets in (18.2.9). Its dimension is m/s. It describe the speed of moving along x_1 axis. The second speed c is light velocity in the movement along screw line around x_1 axis. Perhaps this c should be supplied with special notation to distinguish it from the previous c. Its dimension is m·rad/s. Numerically it is equal the same 3×10^8. We have obtained it as r_e and ω_e product. Let us note that just this combination is included into constant $\hbar$ in (18.1.4). Thus both items in square brackets (18.2.10) has dimension kg·m²·rad/s.

When (18.2.10) is multiplied by radiation frequency ω one obtains two items whose sum describes light wave power

$$1)\ \ p_1(t)=\frac{c\mu\sin\omega t}{r_e^2+\mu^2\sin^2\omega t}\hbar\omega; \tag{18.2.11}$$

$$2)\ \ p_2(t)=\frac{c\mu\sin\omega t\cdot\omega t}{r_e^2+\mu^2\sin^2\omega t}m_ec^2. \tag{18.2.12}$$

Coefficient $\hbar\omega$ here determines the wave thermodynamic energy and m_ec^2 describes its electric part.

One obtains one photon power having integrated (18.2.11) and (18.2.12) overo 2π interval.

18.3. Conclusion on Light

1. Let us note in conclusion that all functions have radian in their dimensions. Physically this means that they describe some rotation, mathematically this means that they are pseudovectors.

2. Light wave has pulsating amplitude described by the coefficient before square brackets. Pulsating character of this coefficient is interpreted in experiment as transverse vibration.

19. Cosmic Background Radiation and Ether

19.1. The Second Plank's Constant

Soon we shall understand that ether is a very dense and elastic media. But in the interval from 2.728 K to 5.9299×10^9 K ether is an ideal gas. An unknown region begins higher. Perhaps dependence of entropy on temperature changes there. Today temperature 2.728 K is linked with concept Big Bang and relic radiation. The field understanding of the problem is that this is the temperature of conversion of the ether into liquid stage. In the ε-vicinity of zero temperature the ether obtains qualities of

rigid body. The characteristics of the thermodynamic field turn to be linked with characteristics of electric field.

In particular this connection is manifested in the following facts. In the meeting of the Academy of Sciences in Berlin on the XVIII[th] of May 1899 Max Planck presented the lecture "On Nonreversible Processes of Radiation" in which he pin pointed the existence of two universal constants which he called "a" and "b". Today constant a is named after him and considered in field thermodynamics as thermodynamic field charge. To say more accurately the value

$$\hbar = a/1\ \text{rad} = 1.0544\times 10^{-34}\ \frac{\text{kg}\cdot\text{m}^2}{\text{s}\cdot\text{rad}}, \qquad (19.1.1)$$

is considered the charge. The ratio

$$q = b/a \qquad (19.1.2)$$

is named after Boltzmann and coincides with our understanding of electric charge (3.2.18). Thus in mechanic dimensions constant

$$b = aq = 1.0544\times 10^{-34}\ \frac{\text{kg}\cdot\text{m}^2}{\text{s}\cdot\text{rad}}\cdot 7.072\times 10^{-10}\ \frac{\text{kg}\cdot\text{rad}}{\text{s}} = \\ = 7.4567\times 10^{-44}\ \frac{\text{kg}^2\cdot\text{m}^2}{\text{s}^2}. \qquad (19.1.3)$$

This value may be interpreted as square of an impulse

$$\sqrt{b} = 2.7303\times 10^{-22}\ \frac{\text{kg}\cdot\text{m}}{\text{s}}. \qquad (19.1.4)$$

Let us mention that constant

$$S_0 = q/\hbar = 6.7072\times 10^{24}\ \text{m}^2\cdot\text{rad}^2 \qquad (19.1.5)$$

is entropy of an ether's particle and invers value

$$S_0^{-1} = 1.4909\times 10^{-25}\ \text{m}^{-2}\cdot\text{rad}^{-2} \qquad (19.1.6)$$

is the wave number of thermodynamic wave in ether. It can be named the third Plank's constant.

Let us return to impulse (19.1.4) and compare it with electron's impulse.

Electron has two rotation impulses: the first one appears because of the rotation of the bigger circumference of the torus:

$$I_1 = m_e\omega_e r_e = 9.1094\times 10^{31}\cdot 7.7634\times 10^{20}\ \text{rad/s}\times \\ \times 3.8616\times 10^{-13}\ \text{m/rad} = \\ = 2.7309\times 10^{-22}\ \frac{\text{kg}\cdot\text{m}\cdot\text{rad}}{\text{s}}. \qquad (19.1.7)$$

Here m_e is electron's mass, ω_e is the bigger circumference's angular velocity, r_e is radius of the bigger circumference. The lesser circumference's impulse value $\mathbf{I}_2$ coincides with $\mathbf{I}_1$ because the lesser circumference radius is twice lesser than of the bigger one but its angular velocity is twice bigger. $\mathbf{I}_1$ and $\mathbf{I}_2$ values coincide but they are applied to different objects.

$$\mathbf{I}_1 = m_e(\boldsymbol{\omega}_e\times\mathbf{r}_e) \qquad (19.1.8)$$

is tangential to bigger circumference and

$$\mathbf{I}_2 = m_e(\boldsymbol{\nu}_e\times\boldsymbol{\rho}_e) \qquad (19.1.9)$$

is tangential to lesser one. Their vector product

$$\mathbf{I}_1\times\mathbf{I}_2 = m_e^2[(\boldsymbol{\omega}_e\times\mathbf{r}_e)\times(\boldsymbol{\nu}_e\times\boldsymbol{\rho}_e)] = \\ = m_e^2[\boldsymbol{\nu}_e(\boldsymbol{\rho}_e\cdot(\boldsymbol{\omega}_e\times\mathbf{r}_e)) - \boldsymbol{\rho}_e(\boldsymbol{\nu}_e\cdot(\boldsymbol{\omega}_e\times\mathbf{r}_e))]. \qquad (19.1.10)$$

This impulse contents two items: rotational directed along $\boldsymbol{\nu}_e$, *i.e.* normal to the lesser circles and polar vector $\boldsymbol{\rho}_e$ directed along radius of the lesser circles. Signs of the coefficients in the inner parentheses defines $\boldsymbol{\nu}_e$ direction, *i.e.* spin direction and $\boldsymbol{\rho}_e$ direction: inside or outside the lesser circles.

Vector product

$$\mathbf{I}_2\times\mathbf{I}_1 = m_e^2[(\boldsymbol{\nu}_e\times\boldsymbol{\rho}_e)\times(\boldsymbol{\omega}_e\times\mathbf{r}_e)] = \\ = m_e^2[\boldsymbol{\omega}_e(\mathbf{r}_e\cdot(\boldsymbol{\nu}_e\times\boldsymbol{\rho}_e)) - \mathbf{r}_e(\boldsymbol{\omega}_e\cdot(\boldsymbol{\nu}_e\times\boldsymbol{\rho}_e))] \qquad (19.1.11)$$

has the same meaning for the bigger circle.

Expressions (19.1.10) and (19.1.11) will be called the first and the second Planck's impulse. If radial projections of Planck's impulses are directed to the center of the circles they fasten electron and strive to demolish in the opposite case. Electron is a stable particle. This means that Planck's impulse stabilize its structure. Positron's bigger circle's frequency

$$\boldsymbol{\omega}_p = -\boldsymbol{\omega}_e, \qquad (19.1.12)$$

This means that positron's Plank's impulse destructs it. Soon we shall see that electron and positron are compressed in ether-1. This compression prescribes positron. Free positron annihilates rather soon.

Last years we observe more and more facts which show that ether-1 consists of electrons or electron-positron pairs. Experiments in which electron and positron appear as a pair witness for defense of the last supposition. In any case the electrons or their pairs creating ether-1 must be noncharged, *i.e.* electrically neutrals.

Let us try to understand how many such "noncharged electrons" can be put into 1 m³ tightly but not hindering each other. Let us find minimal parallelepiped enveloping electron.

This parallelepiped's base is

$$d^2 = [2\cdot(r_e+\rho_e)]^2 = 1.3421\times 10^{-24}\ \text{m}^2. \qquad (19.1.13)$$

Here r_e and ρ_e are radii of the bigger (3.2.8) and the lesser (3.2.7) circles of the electron torus. Multiplying (19.1.4) by the lesser circle diameter one obtains the volume of the parallelepiped:

$$V = d^2\cdot 2\rho_e = 5.1826\times 10^{-37}\ \text{m}^3. \qquad (19.1.14)$$

Dividing 1 m³ by V one obtain the quantity of electrons which can be placed in 1 m³ tightly but not hindering each other

$$N = 1/V = 1.9295\times 10^{36}\ \text{pieces/m}^3. \qquad (19.1.15)$$

Experimental formula (3.2.20) presents us mass of one cube meter of ether-1. Dividing it by 1 electron's mass one obtains

$$N_e = 1.7251\times 10^8\ \frac{\text{kg}\cdot\text{rad}^2}{\text{m}^3} : 9.1094\times 10^{-31}\ \text{kg} = \\ = 1.8938\times 10^{38}\ \frac{\text{pieces}\cdot\text{rad}^2}{\text{m}^3}, \qquad (19.1.16)$$

$$N_e/N = 98.15\ \text{rad}^2. \qquad (19.1.17)$$

This means that ether's particles are packed very tightly. In what plains are they? Dimension of the values in (19.1.15) tells us that the particles of ether-2 creating ether-1 rotates free. But only the

lesser circle of electron rotates in two planes. Thus the pressure takes place only in one plane that is in the plane of the bigger torus circle. We can conclude that particles of ether-1 not only appear by pairs with opposite signs in the pair but they are arranged by pairs in one plane in ether-1. If Coulomb's law is the cause of compression of ether-1 in "electric plain" then evaluation (19.1.15) tells us from what distance electric forces get over Coulomb's forces:

$$l_e = r_e / \sqrt{N_e/N} = r_e/\sqrt{98.18} = 3.9\times 10^{-14} \text{ m.} \qquad (19.1.18)$$

This value is rather close to experimental evaluation action radius of nuclear forces [50].

As (19.1.18) as the fact that pair electron-positron gives birth to proton witness that ether-1 consists of such pairs. We differ ether-1 and ether-2 whose particles create particles of ether-1 and fills the space in and between them. Today we know almost nothing about ether-2. Perhaps it is the base for gravitation.

Let us try to understand the construction of positron entering into ethereal pair. Radius of "electric circle" for both members of the pair is $\sqrt{98.18}$ less than of the free electron. But this does not influence the value of their charge. It depends only on frequency of electron's mass.

In §4, I we supposed that electric charge sign is defined by correlation between electric charge ($\boldsymbol{\omega}_e$) and spin ($\mathbf{v}_e$), i.e. they create left hand or right hand triple. We supposed that right hand triple corresponds electron. This means that left hand triple corresponds to positron. This means that in positron in the pair either its $\boldsymbol{\omega}_p$ should be antidirected to electron's $\boldsymbol{\omega}_e$ or its spin $\mathbf{v}_p$ should be antidirected to electrons spin $\mathbf{v}_e$. In the second case photon born by this pair should have spin zero and the first case photon's spin should be 1 because electron's spin is ½. Experiment witnesses for the first case.

Let us try to answer the question: if tenfold radius lessening influences angular velocity of the bigger circle of the pair members.

In §4, III a photon model as a rotating cylinder oscillating along its axis is proposed. Apparently photon inherits its rotation after the pair's less circle rotation. What offer originate oscillations along the photon axis?

Assumption 1. Photon appears because of the bigger circle breaking in the members of the pair. This broken axis becomes photon's axis.

Let us try to understand the process. The lesser circles of torus in ether-1 are not compressed. Therefore they rotate free. But the bigger circles are compressed.

Assumption 2. Compression of the bigger circle changes its stable rotation for accelerating one in the following way:

$$\omega_e^c = \omega_e \cos(\omega_e t), \qquad (19.1.19)$$

$$\begin{aligned}\omega_p^c &= \omega_p \cos(\omega_p t) = -\omega_e \cos(-\omega_e t) = \\ &= -\omega_e \cos(\omega_e t),\end{aligned} \qquad (19.1.20)$$

i.e. they are accelerated with angular acceleration:

$$\varepsilon_e = \frac{d}{dt}(\omega_e^c) = \frac{d}{dt}(\omega_e \cos(\omega_e t)) = -\omega_e^2 \sin(\omega_e t), \qquad (19.1.21)$$

$$\begin{aligned}\varepsilon_p &= \frac{d}{dt}(\omega_p^c) = \frac{d}{dt}(-\omega_e \cos(-\omega_e t)) = \\ &= \frac{d}{dt}(-\omega_e \cos(+\omega_e t)) = +\omega_e^2 \sin(\omega_e t).\end{aligned} \qquad (19.1.22)$$

The second equity in (19.1.21) and (19.1.22) is valid because is an even function. One obtains for all t

$$\varepsilon_e + \varepsilon_p = 0, \qquad (19.1.23)$$

i.e. sum angular velocity of the pair is constant. One obtains summing (19.1.19) and (19.1.20) in addition

$$\omega_e^c + \omega_p^c = 0. \qquad (19.1.24)$$

The result: although any member in the pair oscillates with angular acceleration electric charge of the pair is zero.

This conclusion helps us to understand some problems with Cooper's pairs in superconductivity theory. Electric neutrality of a particle is necessary condition for it to move in accordance to the first Newton's law [§15]. Ether resists the movement of charges particle. This can be understood already from the Ohm law which links electric current with external forces which set the charges in conductor in motion. Sometimes the cause of it is seen in the conductor's lattice resistance. Although this effect apparently takes place the free ether mainly resists the charges' movement [§15], perhaps namely ether-2 and not ether-1. This resistance is observed in accelerators.

Therefore here we assume that necessary quality of Cooper's pairs in superconductivity effects is their electric neutrality. But if so why magnetic field appears when they move? Today it is widely accepted that magnetic field is strictly linked with electric one. This authors assume that magnetic field is linked with gravitational one. Electron possesses this field because its torus is turned by gravitational force lines just like in solenoid [§16, I]. Therefore Cooper's pairs moving in superconductive media creates magnetic field. It must be similar to the magnetic field of torus solenoid as it is described by E.A. Grigoriev [51]. This field peak is reached inside the torus. But certain part of it manifests outside. It is too small to give evidence in static experiments but it reveals in electron's movement [§15]. E.A. Grigoriev's experiments show that external magnetic field of torus is directed normally to big torus circle. It is possible that just magnetic field compel the big circumference of compressed electron and positron to change uniform rotation for oscillation.

19.2. The Field Heat Equation and Structure of the Eather-1

Initial correlation for heat in field thermodynamics is Eq. (13.3.7). We obtain habitual correlation in terms of energy multiplying left and right hands parts in (13.3.7) by Plank's constant $\hbar$.

One obtains differentiating (13.3.7) with respect to time:

$$\frac{d\omega}{dt} = L\frac{dT}{dt} + T\frac{dL}{dt}, \qquad (19.2.1)$$

$$\frac{dT}{dt} = \frac{\partial T}{\partial y_1}\frac{\partial y_1}{\partial t} + \frac{\partial T}{\partial y_2}\frac{\partial y_2}{\partial t} + \frac{\partial T}{\partial y_3}\frac{\partial y_3}{\partial t} + \frac{\partial T}{\partial t}, \qquad (19.2.2)$$

$$\begin{aligned}\operatorname{grad} T &= \left(\frac{\partial T}{\partial y_1}, \frac{\partial T}{\partial y_2}, \frac{\partial T}{\partial y_3}\right) = \\ &= \left(\frac{\partial T}{x_1 \partial x_2' + x_2' \partial x_1}, \frac{\partial T}{x_2 \partial x_3' + x_3' \partial x_2}, \frac{\partial T}{x_3 \partial x_1' + x_1' \partial x_3}\right).\end{aligned} \tag{19.2.3}$$

Quadratic (plane) derivatives here are expressed by derivatives with respect to two axial coordinate system.

Let us introduce the concept of plane (quadratic) velocity:

$$\begin{cases} \dfrac{dy_1}{dt} = \dfrac{x_1 \partial x_2' + x_2' \partial x_1}{dt} \equiv u_1 \\ \dfrac{dy_2}{dt} = \dfrac{x_2 \partial x_3' + x_3' \partial x_2}{dt} \equiv u_2 \\ \dfrac{dy_3}{dt} = \dfrac{x_3 \partial x_1' + x_1' \partial x_3}{dt} \equiv u_3 \end{cases} \tag{19.2.4}$$

$$\mathbf{u} = (u_1, u_2, u_3), \tag{19.2.4a}$$

Function

$$\mathbf{p} = m\mathbf{u} \tag{19.2.4b}$$

can be named surfacial (quadratic) impulse. Impulse momentum (linear impulse):

$$\mathbf{p} = \mathbf{r} \times m\mathbf{v}, \tag{19.2.4c}$$

is an example of quadratic impulse. Here $\mathbf{r}$ is radius-vector and $\mathbf{v}$ is velocity.

Linear impulse (19.2.4*c*) is at the same time an example of quadratic impulse (19.2.4*b*) for which components $\mathbf{u} = (u_1, u_2, u_3)$ satisfy "consistent condition" mentioned above. Thus

$$\frac{dT}{dt} = \operatorname{grad} T \cdot \mathbf{u} + \frac{\partial T}{\partial t}. \tag{19.2.5}$$

In the same way

$$\frac{dL}{dt} = \operatorname{grad} L \cdot \mathbf{w} + \frac{\partial L}{\partial t}, \tag{19.2.6}$$

Finally (19.2.1) becomes

$$\begin{aligned}\frac{d\omega}{dt} &= L\left(\operatorname{grad} T \cdot \mathbf{u} + \frac{\partial T}{\partial t}\right) + \\ &+ T\left(\frac{dL}{dt} = \operatorname{grad} S \cdot \mathbf{w} + \frac{\partial L}{\partial t}\right).\end{aligned} \tag{19.2.7}$$

In the ideal gas out of phase transition S is the following function of T:

$$L = L_0 \ln(T/T_1), \quad T \in [T_1, T_2], \tag{19.2.8}$$

where L_0 is specific entropy of the medium's particle, T_1 is initial temperature, T_2 is the temperature of phase transition for the medium.

When $T = T_1$ the temperature becomes fixed and heat changes because of the energy change. Therefore when $T = T_2$ grad$T$ becomes zero and grad$L$ and $\mathbf{W}$ begin changing in accordance with their special laws. One obtains using (19.2.8) out of phase transition:

$$\operatorname{grad} L = \frac{L_0}{T} \operatorname{grad} T. \tag{19.2.9}$$

Temperature T and specific entropy L in ideal gas and perhaps in any gas is linked with the gas particles' movement. Therefore in the interval between phase transitions

$$\mathbf{u} = \mathbf{w}. \tag{19.2.10}$$

One obtains from (19.2.7) and (19.2.8) heat change velocity:

$$\begin{aligned}\frac{d\omega}{dt} &= L_0\left[(1 + \ln(T/T_1)) \operatorname{grad} T \cdot \mathbf{u} + \frac{\partial T}{\partial t}\right] + \\ &+ L_0\left[\operatorname{grad} T \cdot \mathbf{w} + \frac{\partial T}{\partial t}\right].\end{aligned} \tag{19.2.11}$$

Temperature and specific entropy of media are connected with its particles' movement. Therefore velocity $\mathbf{u}$ and $\mathbf{w}$ can be considered equal. Thus for ideal gas out of phase transition the heat velocity turns to be function of only temperature:

$$\begin{aligned}\frac{d\omega}{dt} &= 2L_0\left[\operatorname{grad} T \cdot \mathbf{u} + 2\frac{\partial T}{\partial t}\right] + \\ &+ L_0 \ln(T/T_1) \operatorname{grad} T \cdot \mathbf{u}.\end{aligned} \tag{19.2.11a}$$

Let us compare (19.2.11) with Fourier heat conductivity formula:

$$q = -æ \operatorname{grad} T. \tag{19.2.12}$$

Here æ is heat conductivity coefficient. Approximate formula for conductivity coefficient in gases is:

$$æ = \frac{1}{3} \rho c_v \lambda \bar{v}, \tag{19.2.13}$$

where ρ is gas density, c_v is specific heat capacity for constant volume, λ is mean length of the gas molecules' run, $\bar{v}$ is mean heat velocity.

One can see that (19.2.13) is just an averaging of the coefficients in (19.2.11) which describe movement of a separate particle: $\lambda\bar{v}$ is the average of plane velocity $\mathbf{u}$, c_V is the specific entropy of particle L_0, coefficient 1/3 appears as a result of averaging of plane velocity $\mathbf{u}$. If one instead of c_V uses geat capacity coefficient for the case of constant density c_p then coefficient

$$c_p = c_V\left(\ln(T/T_1) + 1\right) \tag{19.2.14}$$

appears in (19.2.13). And this is the first point which differs Fourier formula (19.2.12) from field formula (19.2.11).

The second and more important one is that grad T in (19.2.11) is calculated with respect not to axial but to plane (quadratic) coordinates which introduce plane velocity which describes heat processes more adequately than their averaged values.

Appearance partial time derivatives in (19.2.11) is also essential. The problem is that Fourier law does not take into account inertness of heat conductivity processes. Therefore it is invalid for the high frequency processes' description (ultrasonic processes, shock wave etc.) The first who payed attention to this problem was Maxwell [53]. In 1948 Kattaneo [54] proposed Fourier law version with relaxing member:

$$\tau\frac{\partial q}{\partial t}=-(q+\text{æ}\,\mathrm{grad}\,T). \qquad (19.2.15)$$

If τ is small (19.2.15) coincides with (19.2.12).

(19.2.15) is also can be considered as (19.2.7) averaging. Using probability terms one can say that (19.2.7) describes heat conductivity with the help of random functions and (19.2.15) does it with the help of mean evaluations

Let us consider partial but important case when ether-1 is the heat medium. It is known from the experiment with rarefied gases that heat conductivity of void (eather-1) is close to zero. This means that gradient components in (19.2.7) are close (or even equal) to zero, *i.e.* grad$T$ and grad$L$ must be close to zero. This means that temperature T and specific entropy L of eather-1 are close to constant. Plane velocities **u** and **w** must be also close to zero, *i.e.* ether-1 particles are immovable (fixed). Taking §19.1 into account one can say that eather-1 is a very dense, almost noncompressible close to thermodynamic equilibrium medium. The immovability of eather-1 explains existence of transverse vibrations in light wave.

Heat in such a media is transmitted nevertheless. It takes place because of private derivatives in (19.2.7). It was shown in §19.1 that eather-1 consists of "Couper's couples" pressed by Coulomb force. Rotation of "electric circumferences" of these couples creates Coulomb field and rotation of the lesser circumferences creates temperature and entropy fields which radiates in eather-2 whose qualities are unknown for us today. When we understand qualities of eather-2 we shall better understand structure of photon which is the carrier as for heat as for Coulomb part of electric charge.

19.3. Cosmic Background Radiation is Just the Liquid-Like Phase of the Ether-2

Above we had come to the conclusion that tha basis of Universe is created by ether-1, solid very-very elastic made of Couper's pairs of electron-positron compressed by Coulomb forces almost or even completely not conducting heat with temperature either very close or even equal to zero body. But we see that the Universe in which we live does not coincide with such model, *i.e.* we live in ether-2. Ether-1 is apparently created by the particles of ethe2. In all our observations we apparently see manifestations of ether-2 which we shall call free ether or just ether below.

For this we have already calculated the frontier temperature calorie and entropy under which ether-1 changes its gas-like phase and comes into phase of “overheated vapor” or better to say into plasma phase. This phase transition in particular explains Purcell’s and Pound’s experiment [42] in which particles’ spin in magnetic field change their direction for the opposite one under very high temperature. Earlier supposition about negative temperature was adopted to explain this fact. This chapter point is that phase transition takes place in this case: ether gas transits into oversaturated form in which entropy dependence on temperature changes as it takes place for water and vapor for instance.

The qualities of background radiation detected by Penzias and Wilson [14] leads to the conclusion that there exists the bottom frontier temperature under which calorie decreasing leads to entropy decreasing and transition of gas-like ether into liquid-like phase. This paragraph is devoted to this problem consideration.

Previously we came to the conclusion that gas-like ether into oversaturated phase when

$$T_0=1.147\times10^{-4}\ \mathrm{m^2/s}=5.9299\times10^{9}\ \mathrm{K}. \qquad (19.3.1)$$

Temperature (19.3.1) correspond calorie

$$\omega_0=7.7634\times10^{20}\ \mathrm{rad/s}. \qquad (19.3.2)$$

The entropy (specific entropy $L = S/\hbar$, where S is entropy (§13)) at this point

$$L_0=6.7061\times10^{24}\ \mathrm{rad/m^2}. \qquad (19.3.3)$$

Equalities (19.3.1)–(19.3.3) characterizes the gas-like ether particle at the moment of transition into “plasma” or “oversaturated” phase. These terms are conditional and should not mislead the reader. Ether plasma and used down liquid-like states can essentially differ from traditional plasma and liquid.

Gas-like ether possesses many features of ideal gas. In particular when temperature increases in the interval less T_0 entropy depends on temperature logarithmically

$$\Delta L=L_1\ln(T/T_1),\ T_1<T<T_0. \qquad (19.3.4)$$

Here T_1 is frontier temperature for gas-like ether transition into liquid-like phase and S_1 is entropy in the moment of such transition.

Let us note although this will not be used in future that convex (up) character of logarithmic function is the cause that sum of two volumes of gases with different temperatures have entropy bigger than mean sum entropy of these volumes: straight line joining two points of any convex function lies below its graph. In other terms assertion about inevitable entropy increasing is the consequence of entropy temperature dependence convexity. This is so for ideal gas and for all the media on the basis of which this assertion was adopted. But if there is a medium (perhaps ether in another phase) with other dependence between entropy and temperature (for instance quadratic, *i.e.*, concave (down)) experiments with such medium will lead to opposite conclusion.

We can find entropy increment on the interval [T_1, T_0]:

$$L(T_0)-L(T_1)=L_1\ln(T_0/T_1). \qquad (19.3.5)$$

It was obtained that background radiation temperature

$$T_1=2.728\ \mathrm{K}=5.29\times10^{-14}\ \mathrm{m^2/s}. \qquad (19.3.6)$$

One obtain taking (19.3.5) into account

$$L_1=1.03\times10^{24}\ \mathrm{rad/m^2}. \qquad (19.3.7)$$

One can obtain frontier calorie knowing T_1 and L_1

$$\omega_1=T_1L_1=5.45\times10^{10}\ \mathrm{rad/s}. \qquad (19.3.8)$$

ω_1, T_1, L_1 characterizes separate ether-1 particle when it comes from gas-like to liquid-like phase. Its energy is

$$\omega_1 = 5.72\times10^{-24}\ \text{J}. \tag{19.3.9}$$

One can compare (19.3.8) with the frequencies obtained for background radiation in experiments: from 3.77×10^9 rad/s to 6.28×10^{10} rad/s.

Eq. (19.3.8) is rather close to the up point of the interval. This means that the interval beginning already corresponds to liquid-like ether. The phase transition temperature remains constant. Thus we can find the entropy corresponding the calorie

$$\omega_2 = 3.77\times10^9\ \text{rad/s}. \tag{19.3.10}$$

This entropy is

$$L_2 = \omega_2/T_2 = 7.3\times10^{22}\ \text{rad/m}^2. \tag{19.3.11}$$

And this temperature is

$$T_2 = \omega_2/L_2 = 5.16\times10^{-14}\ \text{m}^2/\text{s} = 2.65\ \text{K}. \tag{19.3.12}$$

We see that the liquid-like fraction temperature is below the frontier temperature 2.725 K which is consider today as cosmic microwave background temperature [55].

Let us try to find some analogies.

1. The closes to ether-1 among habitual substances is Helium. It comes to liquid-like phase approximately under the same temperature. It is possible that superfluid Helium is just ether-1.

2. In order to explain superconductivity we are compelled to adopt some very artificial assumptions. In particular it is connected with Cooper's pairs. There is a basis to believe that ether-1 particles are electrons deprived of their ring rotation and "magnetic winding" [42, §1.5]. Can we suppose that transition to superconductivity just means that ring rotation is suppressed but magnetic winding is conserved in electrons? Such particle without electric charge will move in media without resistance.

CONCLUSION FOR THE BOOK

It is high time to look around to discuss «Kings and cabbage» and to think about our favorite science, *i.e.*, physics. The total retreat of common sense before aggressive mysticism and physical nonsense wrapped into thick layer of mathematics is apparently characteristic feature of the XX^th century physics. And this process is catastrophically expanding. The only way out is to return back to the sources and again tramp. All staged of sometimes ignominious path.

I dare say some words here on the problem and propose my own understanding of the situation Special Relativity Theory will apparently naturally die. It was an artificial excrescence on the living tree of electrodynamics. Thus electrodynamics will shake the dust off and go farther. Certainly gravidynamics must be constructed from the very beginning. I hope that the corresponding chapter of this book will become a durable basis for the new theory. The problem is more difficult with thermodynamics. Its creators put very good stones of experimental facts into its foundation. Historically just thermodynamics had to «fire» earlier then electrodynamics and just from it we have right to wait harvest in the nearest time. It was not by chance that Plank linked his investigations with entropy. It inspired certain optimism in this author that entropy appears in Plank formula in this book. Certainly it will take some time to re-understand experimental facts.

In particular thermodynamic analog of Maxwell equations should be found. Equations uniting electrodynamics, gravidynamics, and thermodynamics would complete this work.

At the end I would like to say the words of gratitude to the editor of Russian version Yegor Pesterev and Cynthia Whitney – editor of English version of this book. They are my lawful coauthors.

Also thank you my reader who have had enough endurance to come to these words.

ETHER'S CHARACTERISTICS

Physical quantity	Value	Reference
Ether		
Free ether mass density (vacuum permittivity)	$\varepsilon_0 = 1.7251 \cdot 10^8\ \mathrm{kg \cdot rad^2/m^3}$	(3.2.11)
Free ether compressibility (vacuum permeability)	$\mu_0 = 6.4498 \cdot 10^{-26}\ \mathrm{m \cdot s^2/(kg \cdot rad^2)}$	(3.2.12)
Physical vacuum impedance	$I = 1.9336 \times 10^{-17}\ \mathrm{m^2 \cdot s/(kg \cdot rad^2)}$	(3.2.13)
Kinematic viscosity	$\nu = 8.5349 \times 10^{-8}\ \mathrm{m^2/(s \cdot rad)}$	(3.2.14)
Dynamic viscosity	$\eta = 14.7235\ \mathrm{kg \cdot rad/(m \cdot s)}$	(3.2.15)
Phase states of free ether a) solid phase b) liquid phase c) gas-like phase d) 4th state	 0 K from 0 K to 2.728 K from 2.728 K to 5.9299×10^9 K from 5.9299×10^9 K to ?	§13, 19
Specific ether's entropy (entropy of one particle)	$S_0 = 6.7061 \times 10^{24}\ \mathrm{rad/m^2}$	(13.6.4)
Dependence of the specific entropy of gas-like ether on temperature	$S = S_0 \ln(T/T_1)$,	(17.1.9)
Electron		
Greater radius	$r_e = 3.8616 \times 10^{-13}\ \mathrm{m}$	(6.10.4)
Angular velocity of the greater circle	$\omega_e = 7.7634 \times 10^{20}\ \mathrm{rad/s}$	(3.2.5) (6.10.3)
The greater circle's rotation velocity	$C_e = 3.1443 \times 10^8\ \mathrm{m/s}$	(6.10.7)
Lesser radius	$\rho_e = 1.9308 \times 10^{-13}\ \mathrm{m}$	(6.10.5)
Angular velocity of the lesser circle	$\Omega_e = 1.5527 \times 10^{21}\ \mathrm{rad/s}$	(6.10.6)
The lesser circle's rotation velocity	$c_e = 2.9979 \times 10^8\ \mathrm{m/s}$	(6.10.7)
Proton		
Greater radius	$r_p = 2.1031 \times 10^{-16}\ \mathrm{m}$	(16.2.1)
Angular velocity of the greater circle	$\omega_p = 4.435 \times 10^{17}\ \mathrm{rad/s}$	(16.2.2)
The greater circle's rotation velocity	$\upsilon_p = 93.2721\ \mathrm{m/s}$	(16.2.3)
Lesser radius	$\rho_p = 7.4355 \times 10^{-17}\ \mathrm{m}$	(16.2.10)
Angular velocity of the lesser circle	$\Omega_p = 5.7019 \times 10^{24}\ \mathrm{rad/s}$	(16.2.11)
The lesser circle's rotation velocity	$u_p = 4.2397 \times 10^8\ \mathrm{m/s}$	(16.2.12)

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